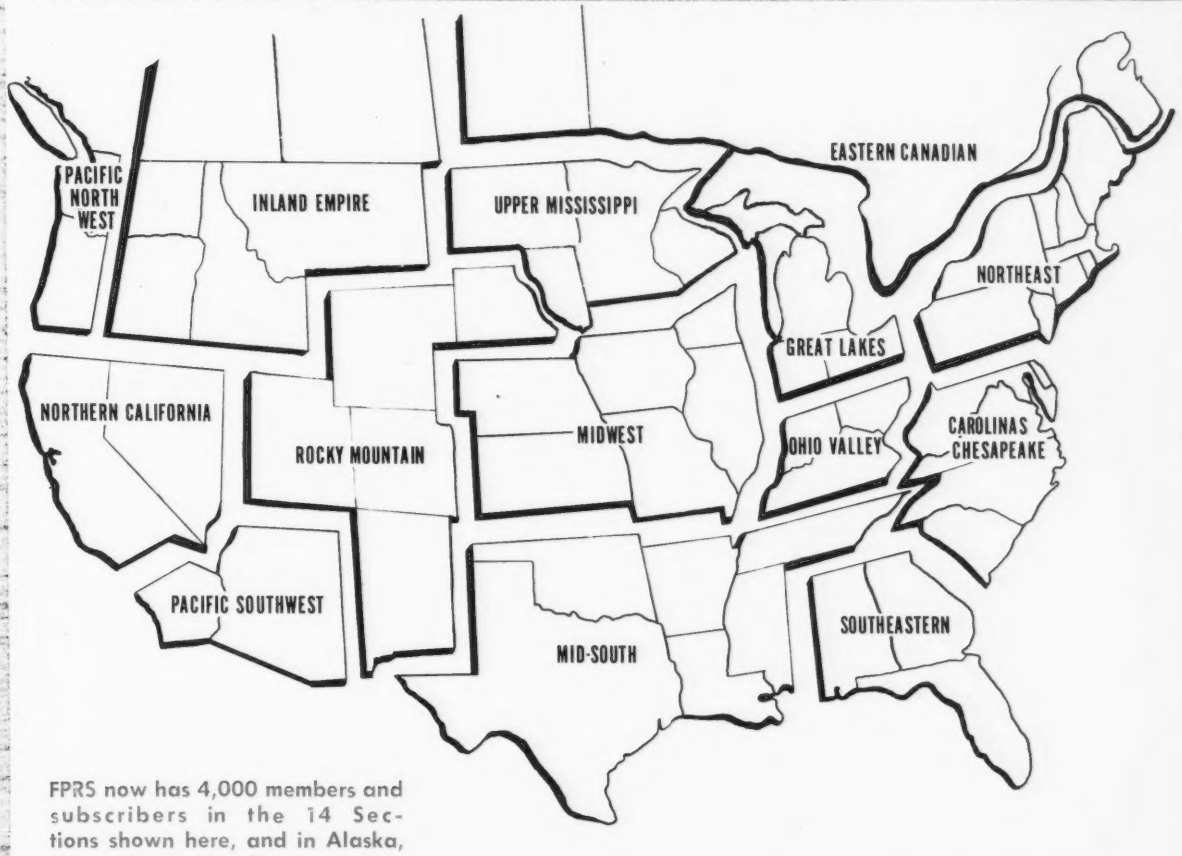
FOREST PRODUCTS JOURNAL

FOREST PRODUCTS RESEARCH SOCIETY

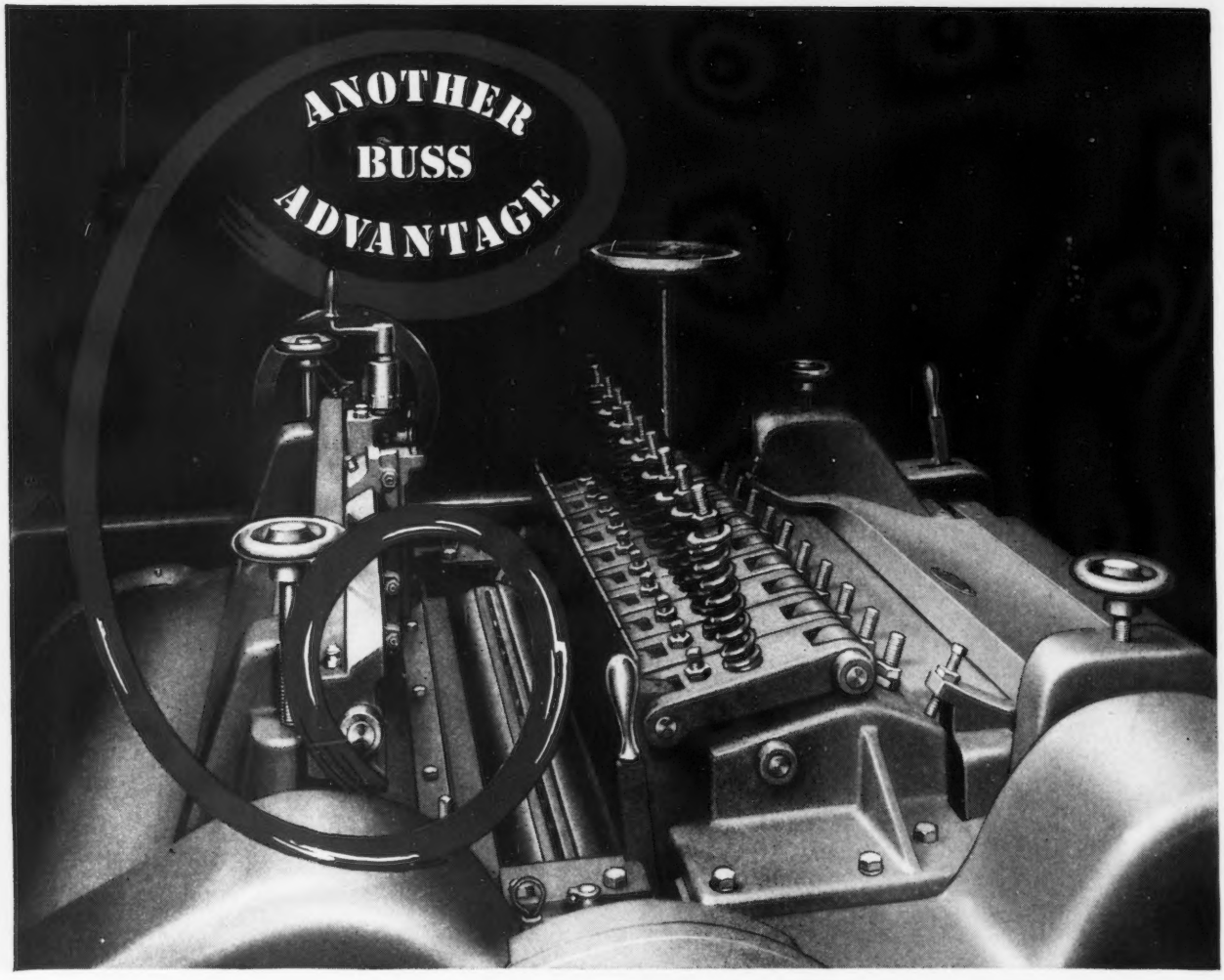


FPRS now has 4,000 members and subscribers in the 14 Sections shown here, and in Alaska, Hawaii, and 41 other free countries throughout the world.

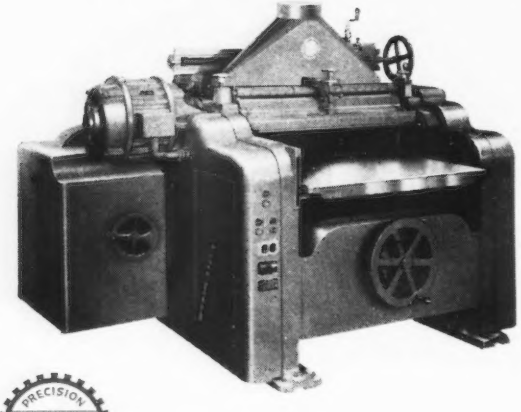
September Yearbook Issue

Vol. XI, No. 9

1961 / SEPTEMBER



PATENTED SHEARING BAR PROTECTS CUTTERHEAD AND PRESSURE BAR



Structural superiority — the built-in profit margin you get with Buss planers. Example? The Buss patented shearing bar — a heavy steel plate, machined to a knife edge, extending the entire length of the cutterhead and bolted above the pressure bar. This shearing bar breaks up loose knots; prevents them from jamming between cutterhead and pressure bar and damaging these parts. Results? Higher quality uniform planing, and "no shaving printing." Why not put Buss advantages to work for you? Write for complete information.

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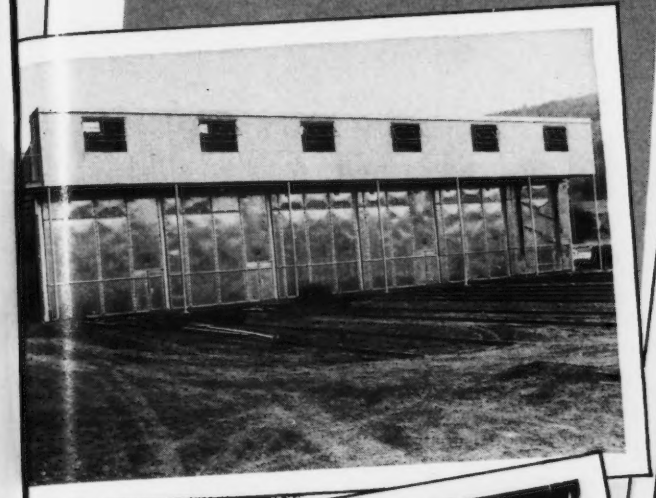

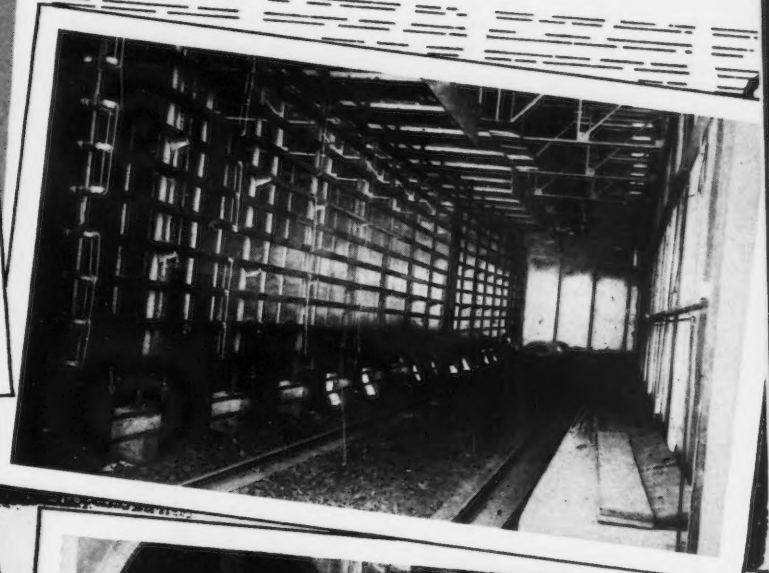

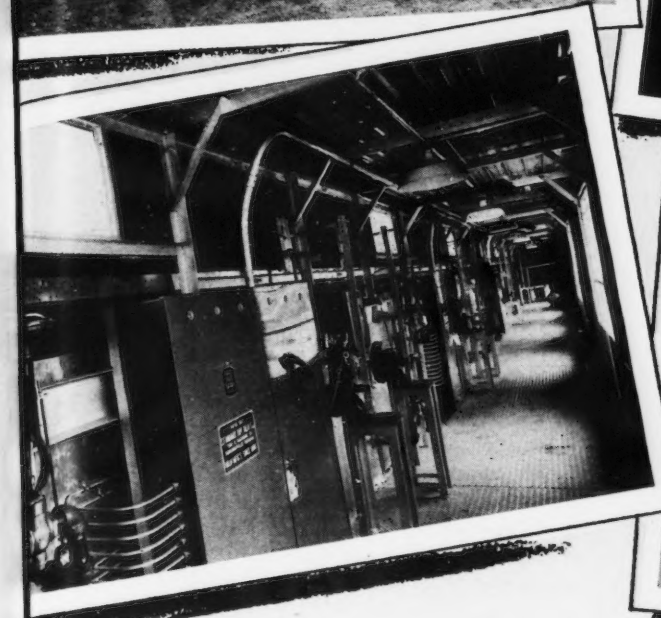

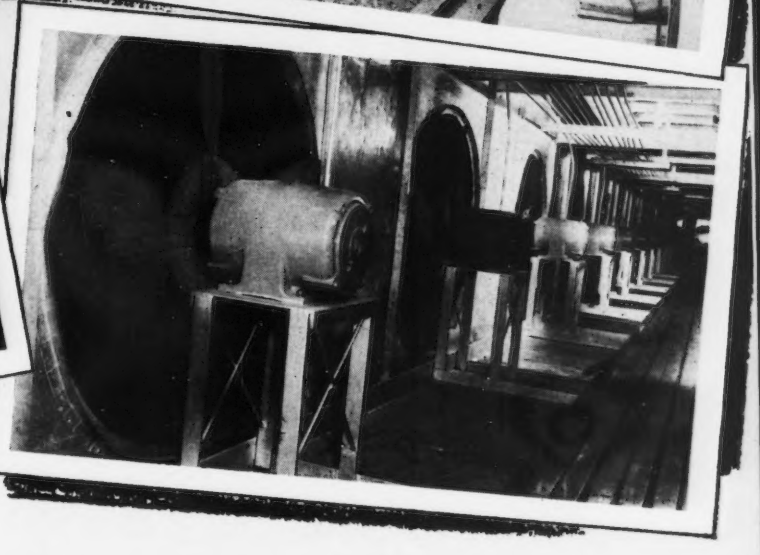

Standard

DRY KILN COMPANY

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Entire kiln installation, including building and all components, was designed and furnished by Standard Dry Kiln Company. Prefabricated unit includes four kilns, 104′ long, with a total holding capacity of 420,000 board feet. Photographs indicate the completeness of Standard's engineering, manufacturing and installation facilities.

The day the lumbermen thought the forests were bare

It happened in the South about 45 years ago.

So much of the timber resources of that region had been exhausted that the lumbermen began to write off the South as a future source of lumber supply.

But trees grow.

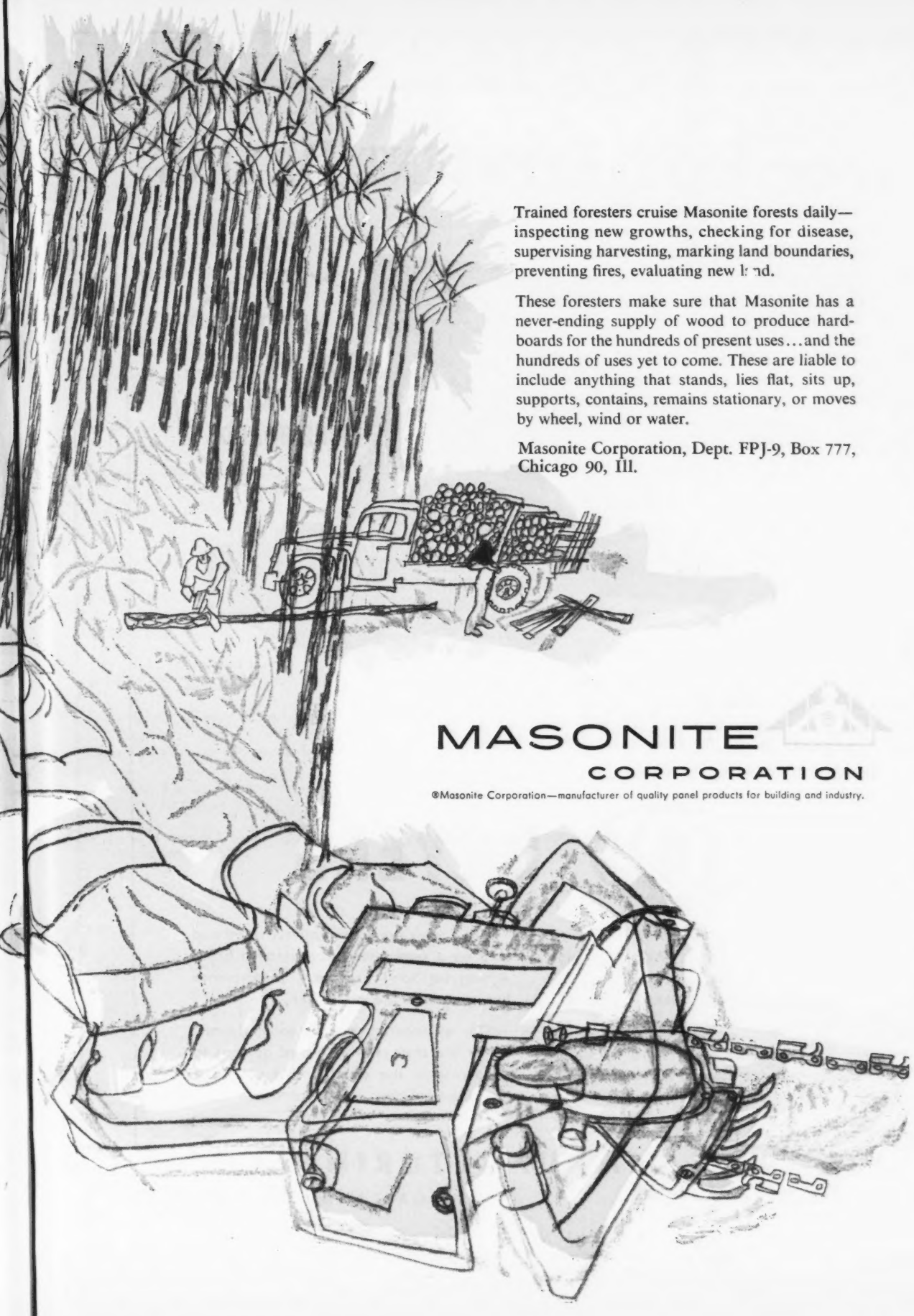
In spite of uncontrolled fires and the lack of forestry programs, trees grow. And one day the timber owners noted that the forests had again thickened. They decided then that if forests could grow again after so many years of waste, misuse and natural disasters, a program of rigid policing would keep them productive indefinitely.

This was the start of scientific tree farming.

At Masonite, tree farming is insurance.

Millions of seedlings, planted every year, mean that growth will always equal cutting.

This is just one facet of Masonite's forestry and reforestation program.



Trained foresters cruise Masonite forests daily—inspecting new growths, checking for disease, supervising harvesting, marking land boundaries, preventing fires, evaluating new land.

These foresters make sure that Masonite has a never-ending supply of wood to produce hardboards for the hundreds of present uses...and the hundreds of uses yet to come. These are liable to include anything that stands, lies flat, sits up, supports, contains, remains stationary, or moves by wheel, wind or water.

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For FAST, EFFICIENT DRYING *of*

VARIOUS WOOD PRODUCTS, VENEERS & FIBRE BOARDS

8 Line Gas Fired Coe Fibreboard Dryer

Wet end 10 section, 4 line, 12 ft. roll Model 48 Coe Veneer Dryer.

Industry Depends Principally Upon

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Since the first Coe continuous dryer was built and sold in 1902 the design, construction and efficiency of these machines have been consistently improved.

Machines are now available in various types and sizes for drying fibreboard and veneer for many purposes including plywood.

Coe Dryers are conservatively rated and sold on a **guaranteed performance basis.** Almost without exception, performance has exceeded the guarantee.

Our engineering and research departments are always willing and anxious to cooperate in the development of drying processes for new wood products.

The COE MANUFACTURING CO.

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FOREST PRODUCTS JOURNAL

Vol. XI, No. 9 September, 1961

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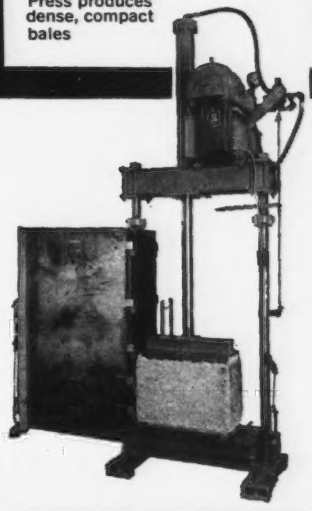
PROFIT FROM WOOD WASTE with CONSOLIDATED BALERS

Duplex Double Chamber Hydraulic Press produces dense, compact bales



Shavings, fibers, wood flour and chips can be turned into a steady source of considerable profit with a modern, low-cost Consolidated hydraulic baling press.

The Consolidated Duplex reduces high-speed baling to practically a push-button operation with complete safety, economy and efficiency, lowest operating costs.

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It's compact . . . only two pieces of equipment are required for a complete setworks. Can be installed in hours instead of days.

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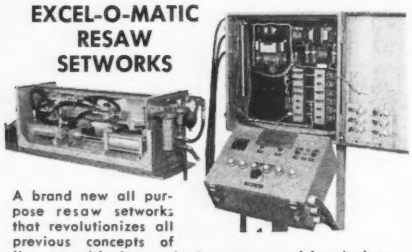

A brand new all purpose resaw setworks that revolutionizes all previous concepts of linear positioning and gives you precision hydraulic positioning with the simplicity of pneumatic power. 2 to 20 pre-set setting positions for linebar; vertical, horizontal resaws. Dust proof control panel can be mounted at any remote position, overhead or pedestal.

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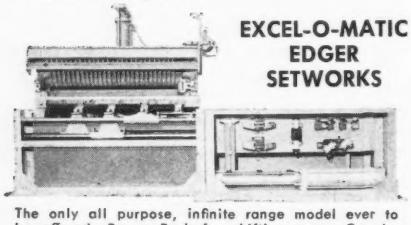

The only all purpose, infinite range model ever to be offered. Power Pack for shifting saws. Can be mounted completely below transfer chain and edger roll elevation. All saws can be positioned in 1/8" increments for full travel on arbor, and positioning can be in reference to either or both sides of infeed table. Control buttons are arranged in 10 multiples similar to manual setting scale for easy operator transition.

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WATCH FOR THESE OCTOBER FEATURES

Which is the best test for water-repellent preservatives?

When and how do you decide to replace a machine?

What problems face the American hardboard industry?

How does heat effect decay resistance of wood?

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A One Year Membership in FPRS

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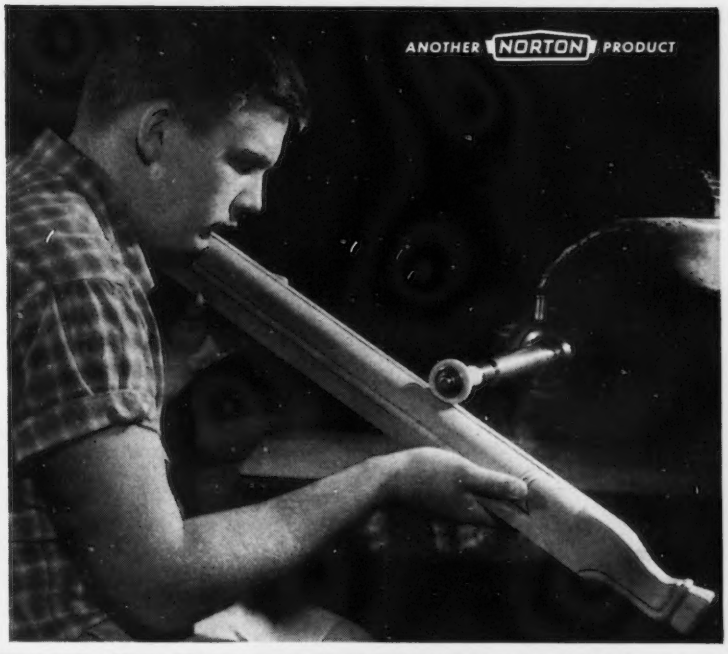

Spindle sanding bead of cherry wood corner post is done here with 2/0 Openkote Adalox Cloth DeLappe disc Singleflex.
(Guard removed for photo.)

Fine furniture like this buffet and bedroom suite has been produced for more than a century by John Widdicomb Co., Grand Rapids, Mich.

ADALOX®. . . a spindle . . . a fine finish!

One of the things about woodworking with BEHR-MANNING coated abrasives is the big variety of time and money-saving methods of doing quality work. Sanding on a spindle is just one of them. And, other nice things about BEHR-MANNING are the large selection of sanding materials available and the many ways by which BEHR-MANNING engineers can help you use them more profitably. Write Dept. FP-9, BEHR-MANNING Co., Troy, N. Y., a division of Norton Company.

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. . . from the President's Desk

Donald K. Saunders

THE THEME of this month's *Journal* is the organization of the Society, with reports on activities of all the segments that are entailed. Important in this are the lists of the individual participants who contribute to these activities.

The volume of work that these people accomplish to pursue the Society's objectives is evident to anyone who scans the reports and lists. One may speculate upon the motives that prompt these efforts; but to a large extent, the only reward is a sense of satisfaction, usually at considerable personal outlay. Here, then, is evidence of faith in the value of the goals of FPRS and in what they mean to the future.

Along with the personal efforts of so many individuals, those members who are directly involved in Society affairs appreciate the confidence shown by our Supporting Members and by the advertisers whose names appear on these pages. Here, we may stress our belief that as far as the forest products element of the economy is concerned, FPRS is the pioneer. We are guided collectively by a conviction that forest products carry a potential still far from fulfillment. Briefly, wood is good.

To relate some of the developments in our industrial techniques to a perusal of past FPRS publications, or to recollect on past meeting discussions, gives a few clues as to how well the Society justifys the confidence of its friends. The striking thing such a review shows is the length of time between some new bits of information and their development to the stage of routine application. The process often must move so slowly that it may try the patience of him who would evaluate our work in terms of specific results. But one must have cognizance of the fact that our Society is mutually interdependent, despite the apparent diversity of our interests—with the flow from learning to application in one direction, and the means to support the pursuit of knowledge in the other.

Effective results of efforts to strengthen the economic position of the industries concerned with forest products cannot be expected to come solely from grand gestures or with dramatic suddenness. Rather they appear more surely from painful attention to small details, from an increasing understanding of the nature of wood, and from the consequent adjustments in techniques developed out of this better understanding.

Eventually, however, new or improved techniques stimulated by broader knowledge should lead industry to better product reliability, and with this to products that permit merchandising that is effective—effective because it is related to advantages that are real.—*Donald K. Saunders.*

Northern California Section to Meet Oct. 20, Fort Bragg

"Utilization of Second Growth," will be the theme of the Northern California Section's annual fall meeting in Fort Bragg, California, on October 20.

NCS Vice-Chairman, Eric L. Ellwood, University of California Forest Products Laboratory, reports that the morning session will be devoted to the presentation of technical papers, and a tour of the Union Lumber Company will be made in the afternoon.

Carolinas–Chesapeake Section Meets in Asheville, Nov. 2–3

The annual meeting of the Carolinas-Chesapeake Section will be held at the Battery Park Hotel, Asheville, N. C., according to a recent announcement from Chairman M. A. Taras, Southeastern Forest Experiment Station, Asheville.

Theme of the meeting will be "Methods for Extending the Use of Wood and Wood Products." Program Chairman R. J. Thomas, School of Forestry, North Carolina State College, has arranged three technical sessions with eight individual papers scheduled for presentation, as listed below.

Technical Session I

"Clean Treatments Against Insects and Decay of Wood Products," by J. Kowal, Southeastern Forest Experiment Station.

"Increasing Wood Durability without Impregnation of Toxic Chemicals," by Dr. R. H. Baechler, U. S. Forest Products Laboratory.

Technical Session II

"Stabilization of Wood Products with Polyethylene Glycol," by H. L. Mitchell, U. S. Forest Products Laboratory.

"Properties, Applications, and Economics of Acetylated Wood," by Dr. I. S. Goldstein, Koppers Co.

"Additional Methods of Wood Stabilization," by Dr. A. J. Stamm, North Carolina State College.

Technical Session III

"Thickness Swelling in Flat-Pressed Flake Board," by Dr. C. A. Hart, North Carolina State College.

"What is High Frequency?" by Dr. C. Skarr, New York State College of Forestry.

"High-Frequency Gluing," by P. Zottu, Industron Corporation.

FPRS News-Digest

FPRS Office Is Test Site In FPL Research Project

FPL TECHNICIANS Roman Baltes, Otto Heyer, and Joseph Jensen have installed a potentiometer in the National Office. Temperatures at eight locations in the walls and roof will be automatically recorded throughout the day for a 5-month period.

When the FPRS headquarters was under construction, thermocouples were placed at various stations in the walls and roof to make it possible to record temperatures during the various seasons. Recently, technicians from the U. S. Forest Products Laboratory connected the thermocouples to a recording potentiometer.

Temperature readings at eight different stations were started in June, and they will be continued throughout the month of October. This is part of a long-term FPL project to determine the extremes of temperatures that may occur in buildings over a period of time in a variety of geographical locations. Similar installations have been made in homes in Arizona, Georgia, Oregon, Texas, and Wisconsin, but the FPRS National Office is the first commercial building so equipped.

FPL technicians hope the project will result in information that will help us design better homes and other structures and to build them with materials best suited for the various climatic conditions throughout the country.

Chapman Foundation Scholarships

Dennis L. Beermann, Lamberton; Orman B. Fixsen, Wabasso; and Larry G. Jaffrey, Rush City have been awarded $300 Chapman Foundation Scholarships for Freshmen Foresters. The trio will enter the University of Minnesota School of Forestry this fall.

Announcement of the awards was made jointly by A. Dale Chapman, president of the Chapman Chemical Co., Memphis, Tenn., and F. H. Kaufert, director of the School of Forestry. Chapman is a 1929 School of Forestry graduate.

The scholarships were established by Chapman to encourage qualified students to prepare for careers in forestry. They are awarded on the basis of academic aptitude, vocational promise, character, leadership and financial need.

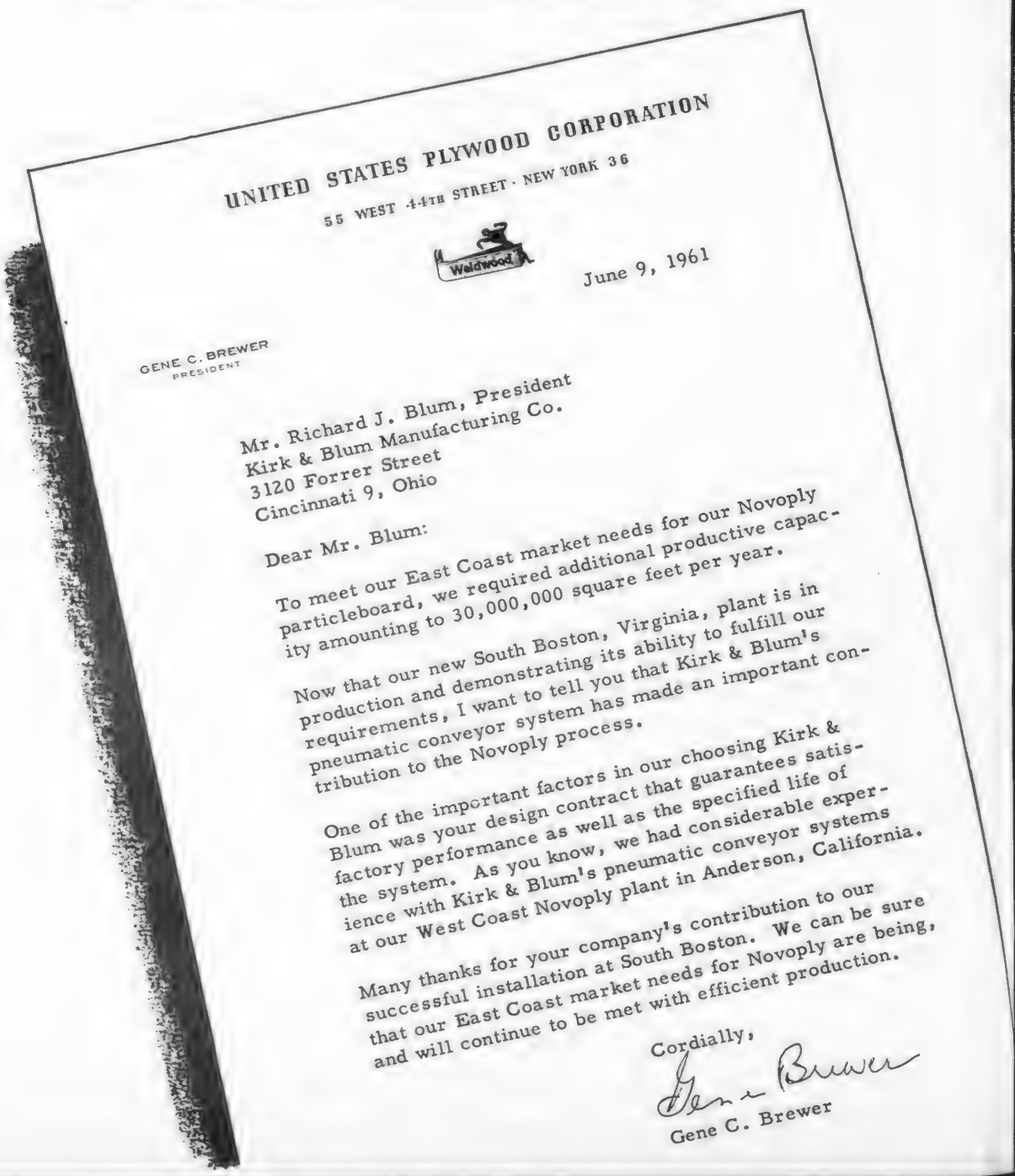
The Chapman Co. manufactures wood preservatives.

"K & B's UNIQUE DESIGN CONTRACT

Under a unique *guaranteed design contract*, Kirk & Blum was retained to design the pneumatic material handling and dust collection systems for U.S. Plywood's new particle board plant at South Boston, Virginia.

By terms of the contract, Kirk & Blum not only designed the pneumatic systems but actually *guaranteed* satisfactory performance and specified life of the systems, construction and installation contractors being required to meet specifications only.

As it turned out, Kirk & Blum was also awarded the fabrication and installation contract on the basis of the lowest acceptable competitive bid . . . thus fulfilling their reputation for one undivided responsibility—design, fabrication, installation.



UNITED STATES PLYWOOD CORPORATION

55 WEST 44TH STREET · NEW YORK 36

Weldwood

June 9, 1961

GENE C. BREWER
PRESIDENT

Mr. Richard J. Blum, President
Kirk & Blum Manufacturing Co.
3120 Forrer Street
Cincinnati 9, Ohio

Dear Mr. Blum:

To meet our East Coast market needs for our Novoply particleboard, we required additional productive capacity amounting to 30,000,000 square feet per year.

Now that our new South Boston, Virginia, plant is in production and demonstrating its ability to fulfill our requirements, I want to tell you that Kirk & Blum's pneumatic conveyor system has made an important contribution to the Novoply process.

One of the important factors in our choosing Kirk & Blum was your design contract that guarantees satisfactory performance as well as the specified life of the system. As you know, we had considerable experience with Kirk & Blum's pneumatic conveyor systems at our West Coast Novoply plant in Anderson, California.

Many thanks for your company's contribution to our successful installation at South Boston. We can be sure that our East Coast market needs for Novoply are being, and will continue to be met with efficient production.

Cordially,

Gene Brewer

Gene C. Brewer

GUARANTEES SATISFACTORY PERFORMANCE"

U. S. PLYWOOD CORPORATION

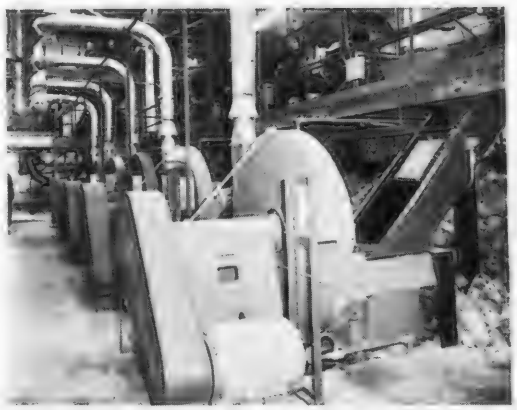
Partial view of U. S. Plywood's South Boston, Virginia, plant indicating magnitude of this Kirk & Blum installation. In addition to tons of standard materials, the K & B system incorporates 68 tons of special abrasive resistant steel for long-life handling of highly abrasive wood products. The total capacity of the installation is 281,000 C.F.M., at various pressures, requiring 630 horsepower.

GUARANTEED AIR SYSTEM

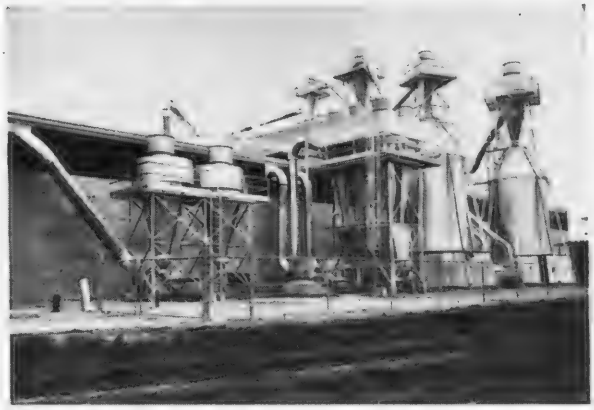
DESIGNED, FABRICATED, INSTALLED by KIRK & BLUM

3,000 tons of material handled daily

10.7 tons of scrap and dust collected per hour



Face material is conveyed from these shavers by the K & B pneumatic system. Approximately 500,000 lbs. of water are removed daily in the course of processing the green wood to a bone-dry finished product.



From left to right are: (1) finishing system collectors, (2) sander dust collectors, and (3) storage silos for face and core materials. The K & B systems are expertly designed to provide maximum public nuisance protection.

KIRK & BLUM

3231 Forrer St., Cincinnati 9, Ohio

FPRS SECTION MEMBERSHIP GOALS

Wanted: 331 New Members by June 1, 1962

Section	New V. & A. Members Section Goal	Percent of Goal Attained	Goal for New Supporting Members	Percent of Goal Attained
Midwest	30	6	3	0
Ohio Valley	10	20	2	0
Great Lakes	20	5	1	0
Upper Mississippi Valley	10	10	1	0
Mid-South	25	12	3	33
Northeast	45	4	5	0
Eastern Canadian	20	0	2	0
Carolinas–Chesapeake	30	3	3	0
Southeastern	10	0	1	0
Pacific Northwest	50	6	5	0
Inland Empire	10	0	1	0
Northern California	20	5	2	0
Rocky Mountain	10	0	1	0
Pacific Southwest	10	10	1	0
Total	300		31	

Membership Chairmen are: Midwest, R. C. Newstedt; Ohio Valley, W. C. Seng; Great Lakes, N. C. Franz; Upper Mississippi Valley, S. H. Wise; Mid-South, H. L. Russell; Northeast, P. H. McCormack; Eastern Canadian, A. E. Glennie; Carolinas–Chesapeake, Sam Freeman; Southeastern, P. J. Bois; Pacific Northwest, Tom McKenna; Inland Empire, R. L. McNett; Northern California, Collins Orton; Rocky Mountain, R. S. Bader; Pacific Southwest, W. E. Ripley, Jr. *Help Your Membership Chairman Meet His Quota!*

NEW OR TRANSFER MEMBERS IN AUGUST

Section Officers please note. Each month we will publish the new or transferred-into-the Section members for the previous complete month. New members are listed in boldface type, transfers in regular type. Letters in parentheses after the members name indicate: (A), associate; (V), voting; (s), student; and (S), supporting.

CAROLINAS–CHESAPEAKE

D. R. Keck (V), Bowaters–Carolina Corp., Bowaters Board Co., Catawba, S. C.

R. L. Odell (s), 2600½ Gervais St., Columbia, S. C.

GREAT LAKES

P. H. Wang (s), 141 Haslett Street, East Lansing, Mich.

D. P. Crownhart (s), 3015 Leahy Street, Muskegon Heights, Mich.

INLAND EMPIRE

W. W. Dostalik (s), Route 3, Box 799–A, Hood River, Ore.

H. M. Ely (V), Edward Hines Lumber Co., Dee Division, P. O. Box 210, Hood River, Ore.

MID-SOUTH

A. C. Mackin (V), Cummer–Graham Co., P. O. Box 218, Paris, Tex.

G. C. Romeiser, (V), Southern Hardwood Producers, Inc., 805 Sterick Building, Memphis, Tenn.

MIDWEST

Arthur Pais (V), Laminite Plastics Corp., 2607 W. Monroe, Chicago 12, Ill.

C. H. Stoltenberg (V), Forestry Dept., Iowa State Univ., Ames, Iowa

L. R. Gjovik (s), 4322 Mohawk Drive, Madison, Wis.

R. O. Woodfin, Jr. (s), 5406 Marsha Dr., Madison 5, Wis.

NORTHEAST

H .T. Peters (V), The Singer Mfg. Co., 321 First Street, Elizabeth, N. J.

OHIO VALLEY

L. R. Thomas (V), Thomas Sales & Engr. Co., 1300 So. 12th Street, Louisville, Ky.

B. D. Taylor (s), HQ: HQ Bty, 2nd How Bn., 11th Arty, Fort Campbell, Ky.

PACIFIC NORTHWEST

C. K. Huszar (s), 316 So. 10th St., Corvallis, Ore.

Richard Arney (V), Galice Ranger Station, Merlin, Ore.

H. A. Chase (V), Weyerhaeuser Co., Tech. Center, Box 1139, Longview, Wash.

D. M. Fisher, Jr. (V), c/o Weyerhaeuser Co., Everett, Wash.

J. L. Leslie (V), 952 Hudson Ave., Longview, Wash.

PACIFIC SOUTHWEST

J. D. Getz (V), Calif. Panel & Veneer Co., 3541 Brookhill Street, La Crescenta, Calif.

M. J. Zwolinski (s), 2904 N. Palo Verde Ave., Tucson, Ariz.

ROCKY MOUNTAIN

Roger Shepard (s), U. S. Forest Service, Deadwood, S. D.

SOUTHEASTERN

L. K. Larson (s), c/o Pomeroy & McGowin, 951 Government Street, Mobile, Ala.

W. O. Osterman (s), 723 E. Hardin Ave., College Park, Ga.

UPPER MISSISSIPPI VALLEY

R. M. Reddin (V), Androc Chemical Co., 7301 W. Lake Street, St. Louis Park 26, Minn.

J. K. Dillman (s), 200 South Vine, Marshfield, Wis.

P. C. Kersavage (s), 5300 Elliot Ave., So. Minneapolis 17, Minn.

James C. Ward (V), Lake States Experiment Sta., 802 First Street, Wausau, Wis.

Adhesives and Coatings Theme of UMV Meeting

The Upper Mississppi Valley Section of FPRS will hold their annual fall meeting September 22 at the Central Research Laboratory of the Minnesota Mining and Manufacturing Co., near St. Paul.

The general theme of the meeting will be the fundamental and future aspects of adhesives and coatings. The technical session, scheduled for Friday afternoon, will be highlighted by a 3-hour presentation by 3M technologists in charge of research on coatings and adhesives. This will be followed by a question and answer period on actual production problems.

Evening activities will include a social hour and banquet at the famous White Pine Inn, Bayport, Minn. Guest speaker will be Robert Ruford, University of Minnesota geologist, who recently spent 6 months in Antarctica.

For additional information contact: John Neetzel, University of Minnesota Farm Campus, St. Paul; or, Steve Wise, Wood Conversion Co., Cloquet, Minn.

WHEN YOU TALK BEAUTY AND DURABILITY FIBERESIN SPEAKS YOUR LANGUAGE

You have only to look at furniture built with solid **Fiberesin** to notice its inherent beauty, the surfaces are flat and ripple-free, and the finish is satiny-smooth with a warm-to-the-touch feeling. You choose from the widest selection of wood grains, patterns, and colors available to meet any decorative or aesthetic requirement – antique Provincial to bold Contemporary. With this beauty is built-in **Fiberesin*** durability. **Fiberesin** is virtually "people-proof". Its surface cannot be ringed by a wet glass or even a piping hot cup of coffee. A forgotten cigarette cannot harm the **Fiberesin** surface, nor can fruit acids, alcohol, grease, cosmetics, or fingernail polish and remover. **Fiberesin** withstands an amazing amount of abrasion and will absorb bumps and knocks that would destroy other materials. A **Fiberesin** panel will not warp or twist . . . cannot separate or sliver.

Whatever your furniture requirements . . . hotel, motel, institutional, dormitory, classroom, home or office, we suggest you consider and specify solid **Fiberesin** . . . the structural plastic panel that speaks your language.

DEVELOPED AND PIONEERED BY

of course it's Fiberesin FIBERESIN® PLASTICS COMPANY *Write for the complete story today.*

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*Fiberesin meets or exceeds all pertinent commercial standards for melamine high pressure decorative laminates. Fiberesin meets all specifications and requirements of Federal Specification L-T-0041c (GSA-FSS) Type III.

National Starch and Chemical to Build Monomer Plant

National Starch and Chemical Corporation today announced plans to build a $4,000,000 vinyl acetate monomer plant. Donald D. Pascal, president, said that the annual capacity of the new chemical plant will be 45,000,000 lbs.

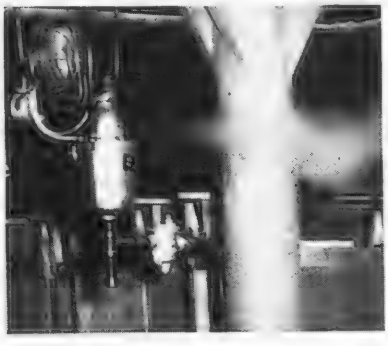
One of two sites currently under study in Texas will be selected for the location of the plant. Construction, which will be handled by Brown and Root, Inc., is scheduled to commence late this year, and the new facility is expected to be in operation during the fall of 1962.

National Starch and Chemical, a leading producer of polyvinyl acetate polymers and copolymers, began research on these products as early as 1942. The company built its first polymer plant in 1946 at Plainfield, New Jersey. A second plant was built at Meredosia, Illinois in 1954, and as the result of several expansions capacity has now been quadrupled.

To the Executive Concerned With Improving Profits

How would you like an investment that returns the principal the first year and pays 100% each successive year?

If your plant is in an area where outside temperature in winter falls well below freezing, you can make such an investment.



The investment?

Armstrong Humidification for your plant.

Your production people can tell you what dry air in the plant during the heating season means in terms of stock losses, gluing problems, and excessive repairs. Scores of users have told us that the cost of Armstrong Humidification is *no more than the cost of one season's losses resulting from dry air.*

You can get a more accurate indication of the investment required by asking us to have an Armstrong Representative to make a humidification survey of your plant. Do it, today. We think you'll be pleasantly surprised at what a small investment is necessary to start earning big returns.

ARMSTRONG STEAM HUMIDIFIERS

Manufactured and Guaranteed by
the Makers of Armstrong Steam Traps
ARMSTRONG MACHINE WORKS
9563 Maple Street • Three Rivers, Michigan

Upturn for Plywood

Western plywood manufacturers, off the ropes after a year-long pummeling from glutted markets and vanishing profit margins, are looking ahead with lighter hearts. A rosy picture free of the black overtones of 1960 was painted at the 25th annual meeting of the Douglas Fir Plywood Association, which drew nearly 300 executives of member mills to Gearhart, Oregon.

The best housing year since 1950's record prosperity—with a prospect of even better things a year later—was forecast for 1961 by Carl T. Mitnick, past president of the National Association of Home Builders and one of the country's foremost builders.

A new DFPA-developed building system aimed at helping stabilize costs for material suppliers and builders was unveiled by Stanley A. Taylor, DFPA field promotion director. A prediction that "all progress in building will come in the field of components," along with a statement that DFPA "is far in front in the component field," came from James M. Lange, vice president and editor of *Practical Builder* magazine.

Mitnick, whose accurate forecast of 1960's housing downturn drew hot criticism two years ago, praised the Kennedy administration's appointments in the housing field and supported efforts to cut interest rates and extend FHA mortgage terms to 40 years.

Buried Hatchet

"The old bureaucratic feud between Agriculture and Interior—between forestry and park services—is now a dead issue", Agriculture Secretary Freeman stated in an addresss recently to farm radio and television newscasters. He and Secretary Udall had just returned from a tour of western National Parks and Forests.

Secretary Freeman, in requesting support for "action to meet the problem of the nation's recreational 'deficit' as well as its agricultural 'surpluses'," commended Secretary Udall for his vigorous and farsighted approach to strengthening the National Park System, and stated: "The Department of Agriculture is proud and happy to join forces with the Department of the Interior so that recreational resources under the jurisdiction of both departments can be developed as rapidly as possible."

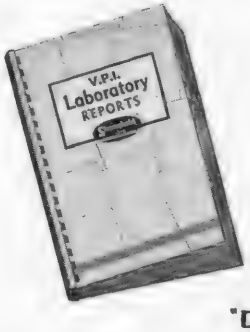
The Department of the Interior and the National Park Service have long sought Department of Agriculture lands within the National Forests suitable for park purposes.

THIS HELPFUL LITERATURE

Yours for the asking

MANY ARCHITECTS and others are finding this authoritative literature on new and better fastening methods helpful. It tells how STRONGHOLD® Annular Thread and SCREW-TITE® Spiral Thread Nails make house frames stronger, keep floors and underlayment smooth and squeak-free, virtually eliminate "popping" nail heads in gypsum board drywall, hold shingles secure in winds up to three times hurricane force — often with fewer nails, slimmer nails, shorter nails — and with important savings in time, labor and materials. STRONGHOLD and SCREW-TITE Nails have revolutionized fastening methods. This literature shows you *why*. Write us for it.

Several of the pieces shown have won awards in PC-AIA and/or PC-NAHB literature contests.



Practically all of the authoritative data available on the holding power of threaded nails is the result of the continuing program of research sponsored by us, and reported in these VPI Bulletins. Ask us for a bound copy.

Sample board at right is 12 x 18 inches, has actual samples of nearly 50 "Stronghold Line" improved fastenings that hold better, tighter, longer — enable you to use new cost-saving techniques and materials.

for Shingles, Shakes and Siding
THE
Stronghold
Line
BETTER FASTENINGS FOR EVERY PURPOSE
STRONGHOLD and SCREW-TITE Framing Nails
"Drives Like A Nail . . . Holds Like A Screw"
STRONGHOLD and SCREW-TITE NAILS for ALL TYPES of ROOFING
STRONGHOLD Drywall Nails
INDEPENDENT NAIL & PACKING CO.

"Drives Like a Nail...Holds Like a Screw®"

Made only by

Independent Nail & Packing Company

Pioneer Developers and Largest Manufacturers of Threaded Nails

BRIDGEWATER, MASSACHUSETTS

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Quality Control Conference

Outstanding quality control experts and statisticians from a wide range of industries, universities and military installations will address the nearly 500 persons attending the 16th Midwest Conference of the American Society for Quality Control, October 19–20, at the Chase-Park Plaza Hotel, St. Louis, Mo. Speakers on subjects ranging from "Statistics and Sex" and "Statistics and the Stock Market," through "Effective Installation of Quality Control," will develop the theme of the Conference, "The Universality of Statistics."

The ASQC is a national organization which encourages the development of statistical techniques to improve quality control in our nation's industrial processes. The Midwest Conference is part of its continuing program for the interchange of valuable information.

Scott Lumber Introduces New Prefinished Panels

The announcement of a unique new building material came today from Scott Lumber Company, Inc. Burney, California. The product bears the trade name "Shastawood," and is a prefinished wall paneling available in fourteen different combinations of wood varieties, colors and styles.

According to Raymond H. Berry, Vice President and General Manager of Scott Lumber Company, Inc., the new Product is being manufactured in a $350,000.00 plant constructed especially for the purpose at Burney. He indicated that 1961 production would exceed 5,000,000 board feet, with annual production thereafter estimated at 10,000,000 feet.

The product is a 7⅜″ face, tongue and groove wall paneling, 7′, 8′ and 10′ long, available in Incense Cedar and White Fir. Six layers of the paneling are packaged in a three-color, fibreboard carton designed for display in retail outlets. One of the six layers will have short lengths.

Berry pointed out that panels are available in two patterns—a "Modern" style with a slightly concave surface, and a "Classic" with a double French curve on the surface of the panel. Designs were developed by John Normile, A.I.A., former Building Editor of Better Homes and Gardens, and J. J. Allegretti, Scott's Director of Special Products.

Allegretti said the paneling produces a wall of solid wood ¾″ thick with a sculptured surface giving a desirable play of light and shadow. The material contains random knots and pecks and other natural wood characteristics.

At the new plant the paneling is moved automatically through spray booths that apply a light pastel coloring and then through a second spray booth where each panel is given a clear plastic resin finish, after which the material is sent through one of the largest infra-red ovens in Northern California and baked to a hard, impervious surface. The plastic finish forms a permanent bond that will not chip, crack or flake in normal use and requires a minimum of maintenance and may be wiped clean of lipstick, nail polish, coffee, crayon and most common household stains.

Speakers Announced for Midwest Section Meet

Producers and users of hardboard, particle board and insulating board will exchange ideas on common problems at a 2-day symposium on Wood Composition Boards to be staged by the Midwest Section of FPRS at famed McCormick Place, Chicago, October 19–20, according to Midwest Chairman Willard C. Gullicksen.

James C. Elf, meeting chairman, reports a well-rounded panel of speakers representing both producers and users has been lined up in an all-star program covering three sessions—a producer panel on the first morning, a user panel that afternoon, and a wide-open question-and-answer clinic the second morning. The following speakers are included.

Producers: Andrew Watts, Masonite Corp.; Robert LaCosse, Insulation Board Institute; Walter Grubman, National Starch & Chemical Corp., and Richard Campbell, Southern Plaswood Corp.

Users: Andrew Place, Place & Co.; Jack Halberg, Hamilton Mfg. Co.; Paul Ecker, Curtis Cos., Inc.; Arthur Pais, Laminite Plastics Corp.; Vincent Washburn, Hammond Organ Co.; Wayne Swett, Marlette Coach Co.; R. E. Palmer, Henry County Plywood Corp.

Wayne Lewis, U. S. Forest Products Laboratory, will open the meeting with a discourse on composition board trends and developments. The luncheon on the opening day will feature a talk on marketing by Harry C. Smith, Braun & Aldridge, Inc., Orland Park, Ill. A special added attraction will be a discussion on finishing of board and panel products by C. O. Hutchinson, Glidden Co.

The Midwest Section's annual business meeting will be held the afternoon of October 19.

Holiday Heralds Wood

The superior qualities of wood for home interiors and for fine furniture is the subject of a feature article in the August issue of Holiday Magazine. Readers are told about the use of various woods to beautify walls, ceilings, and floors, with particular emphasis on veneer plywoods and individual qualities. A series of photographs of home interiors show a variety of woods "at home," and a checklist with basic information about 20 popular woods is included.

The author, philosophizing on the enduring popularity of wood, notes that as far back as man can remember, wood has been a mainstay in his life. It has sheltered him from the elements, and lent beauty and warmth to his existence indoors, and continues to do so. It is the organic nature of wood that has made it the constant preference for decorators and architecture. "Wood never dies. It is forever a living substance, never completely divorced from the tree that gave it birth and brought it to maturity . . . When worked and enhanced as paneling, flooring, or furniture, it carries with it the feel of the forest. The grain, the luster and sense of depth—all remind us of wood's origin."

"Fine wood used to be an arcane mystery reserved to the carpenter, the carver, the cabinet maker and the furniture manufacturer. Through scientific experimentation and mass production, it is now within the reach of almost anyone . . . The turning point came in 1945 when the first prefinished plywood paneling, ready for installation on interior walls, was produced by an American company . . . Homeowners who want a continuous, matching pattern in paneling can find it in plywood . . . Except to a practiced eye, the difference between veneer plywood and solid paneling is hard to detect.

"Fine wood will probably continue to bring greatest pleasure as furniture. More than a dozen established firms specialize in custom cabinet work in the United States today. . . . Legs and arms are always of solid wood, which can be carved or turned, but veneer is preferred for tables or cabinet tops or sides because solid wood expands and contracts . . .

"New uses for wood are constantly expanding the furniture market . . . As the tree envelops with shade the ground beneath it, so the wood of the tree envelops our civilization—. . ."

Hal Burton is the author of this beautifully illustrated article with its exemplary views on the versatility of wood.

FALK
...a good name in industry

QUALITY GEAR DRIVES and FLEXIBLE SHAFT COUPLINGS

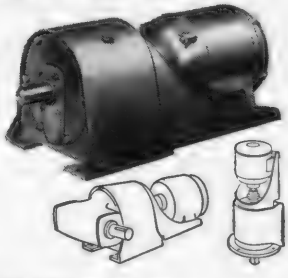
THE FALK CORPORATION, MILWAUKEE 1, WIS. *Representatives and Distributors in many principal cities.*

● The helical and spiral bevel gears in Falk gear drives assure maximum mechanical efficiency attainable—98½% per gear mesh under full load.

ALL-MOTOR MOTOREDUCERS *up to 125 hp.*

All-steel units for use with any NEMA foot-mounted motors within rated capacities of the gear drives. Standard output speeds from 1 to 780 rpm (with 1750 rpm motors); as low as .032 rpm in semi-standard designs. Also Integral units, from 1 to 40 hp.

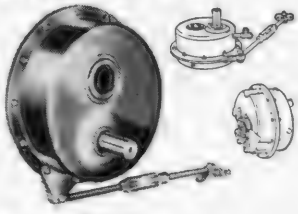
Ask for Bulletin 3100.



SHAFT MOUNTED DRIVES *up to 125 hp.*

All-steel units, horizontal or vertical. Output speeds between 420 and 5 rpm. Maximum torque rating at low speed shaft: 100,000 lb-in. Consult Factory for higher capacities and for flange mounted drives.

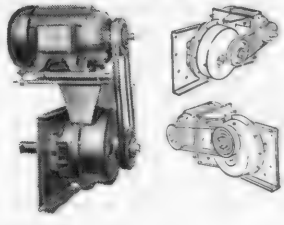
Ask for Bulletin 7100.



SCREW CONVEYOR DRIVES *up to 40 hp.*

Bolt to any standard trough end. Output speeds from 420 to 5 rpm. Max. torque rating at low speed shaft: 44,000 lb-in. Drive includes removable drive shaft and seal housing with choice of seals. Trough end and Motor Mount optional.

Ask for Bulletin 7106.



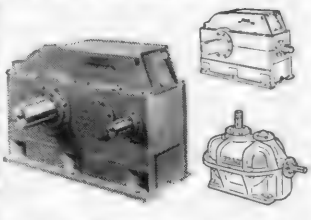
SMALL SPEED REDUCERS *up to 350 hp.*

Concentric Shaft reducers with ratios from 1.49:1 to 970:1. Maximum torque at low speed shaft: 94,000 lb-in. **Right Angle** ratios from 5:1 to 1460:1. Maximum torque at low speed shaft: 73,000 lb-in.

Ask for Bulletin 1105.

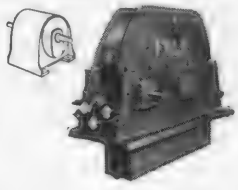
LARGE SPEED REDUCERS *up to 5800 hp.*

Parallel Shaft up to 5800 hp. Ratio range: from 2:1 to 292:1. Maximum catalog torque at low speed shaft: 1,570,000 lb-in. Bulletin 1100. **Right Angle Horizontal** up to 1900 hp. Ratio range from 5:1 to 1200:1. Max. catalog torque at low speed shaft: 1,570,000 lb-in. Bulletin 2100. **Right Angle Vertical** up to 760 hp. Ratio range from 6:1 to 430:1. Max. catalog torque at low speed shaft: 714,000 lb-in. Low speed shaft extension up or down. Bulletin 2110.



HIGH SPEED DRIVES ... *reducers or increasers.*

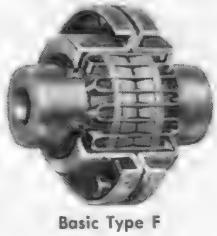
Parallel Shaft drives cataloged up to 5,000 hp or 10,000 rpm. Unit ratios from 1.15:1 to 12:1. Bulletin 5105. **Concentric Shaft** units cataloged up to 225 hp or 4500 rpm. Ratios from 1.5:1 to 25:1. Bulletin 1106.



STEELFLEX COUPLINGS *protect connected machines.*

Hp range: ½ through 72,000 hp at 100 rpm. Exclusive grid-groove design cushions shock loads, accommodates reasonable degrees of shaft misalignment. Basic Type F for 9 out of 10 industrial applications, horizontal or vertical.

Ask for Bulletin 4100.



Basic Type F

AIRFLEX COUPLINGS *Designed for mounting shaft-to-shaft, shaft-to-flywheel, or shaft-to-flange.*

15 sizes covering a range from 5 through 2880 hp at 100 rpm. Ideal for applications which have irregular torque characteristics in driving or driven machines (internal combustion engines, reciprocating compressors, etc.).

Ask for Bulletin 8100.

SINGLE HELICAL and HERRINGBONE GEARS

Exclusive Falk extra-depth, high pressure angle gear teeth provide greater strength and protection against abrasion. AGMA ratings. Hub or ring gears in solid or split designs.

Diameters up to 23'-9" PD.

Face widths up to 6'.

Diametral Pitch: ¾ to 6 DP.

Ask for Engineering Reports 6170 and 6171

Ring Gears

Hub Gears

Special GEAR DRIVES for any application.

Special HIGH SPEED DRIVES ... over 50,000 rpm.

Marine PROPULSION DRIVES for turbine and diesel.

FALK, ALL-MOTOR, and STEELFLEX are registered trademarks.

Brown Stain Prevention

An effective preventive against brown stain in hemlock lumber has been reported by Rayonier Canada Limited's Research Division. In their report, the researchers stressed that there is no evidence to suggest that the stain is an inherent property of the hemlock. Rather, their laboratory studies suggest that brown stain results from a bacterial infection.

The research program disclosed that the usual preservative treatments to prevent blue stain of fungus origin were ineffectual against brown stain and further investigation showed that sodium azide, considered effective against brown stain of pine sapwood, provided no prevention of the stain in hemlock sapwood. Of the numerous chemical agents tested by Rayonier Canada, Thiourea was found to be the effective preventive. Treatment of green hemlock sapwood with this agent was effective in reducing an incidence of 60 percent brown stain when stacked in a mill yard to less than 10 percent.

Brown stain, according to Rayonier Canada's studies, might be caused by an oxidation of some sap components in hemlock which have been modified by bacteria. Thus an enzyme poison or antioxidant seemed worth trying. At the outset, the researchers devised a simple test wherein wood which would develop stain could be distinguished from that wood which resisted staining. It was then found that the staining wood generally had higher bacterial counts than wood resistant to stain.

Fire Test

A fire test sponsored by the National Lumber Manufacturers Association and the National Wood Promotion Program at Southwest Research Institute, San Antonio, has demonstrated conclusively that an unprotected heavy timber glulam beam has more fire resistance than an unprotected rolled structural steel beam. A wood beam and a steel beam were tested simultaneously under identical fire exposure and under equal loading conditions. The wood beam was 7 inches wide, 21 inches deep and was made of nominal 2-inch lumber, without chemical treatment, and glued together with a casein adhesive. The rolled structural steel beam was a 16-inch deep, wide flange member weighing 40 pounds per linear foot.

The beams were tested over a span of 43 feet, 3 inches. Each beam carried a roof area 6 feet wide and 43¼ feet long and was loaded with bags of sand to provide 30 pounds per square foot of roof area plus the weight of the beam and roof slab. Both beams were designed in accordance with accepted engineering practice. Fire exposure was provided through gas burners and temperatures within the test chamber were regulated to follow the Standard Time-Temperature Curve recommended by the American Society for Testing Materials.

Within several minutes after the gas burners were lighted the steel beam started to sag and this deformation gradually increased until, at the end of 29 minutes, it had reached approximately 36 inches. At the end of 30 minutes the steel beam with its roof slab collapsed into the test chamber.

The glulam wood beam showed very small deformation even though exposed to severe fire. At the end of 30 minutes, when the steel beam dropped, the wood beam was still supporting its load and its deformation was only 2¾ inches. After removal from the test structure the wood beam was sawed through at about mid-length and showed a depth of char of approximately ¾ inch on each side and on the bottom.

If it's a question about wood preservatives...

See the man from WOOD TREATING

PENTACHOROPHENOL
Recognized as the leading preservative for protecting wood against decay and rot, termites and other wood-boring insects. Clean . . . won't stain . . . contains 5% Pentachlorophenol in a solvent base.

PRESSTREAT
Combination of PENTA **plus** water repellents for pressure treatment of lumber. Provides super above-and-below-ground protection against termites, other wood-boring insects, decay and fungus.

NOXTANE
Controls ugly blue-black sap stains and mold. Keeps lumber bright and clear . . . stops costly degrading. Contains no arsenic or mercury—non-irritating and dustless—resists leaching from rain.

WOODTREAT A
A 10% Penta emulsion paste. Gives maximum protection to standing poles, piling, cutoffs, structural timbers. Applied by hand scoop, brush, paddle or mechanical spray. Clean to handle . . . not highly toxic.

TECHNICAL COUNSEL
Experienced specialists **plus** the most modern and complete laboratory facilities, are available for counsel and help on any wood preservation problem.

For more information, write or phone...
Wood Treating Chemicals Co.
3137 Southwest Ave. • St. Louis 10, Mo.

WOOD TREATING

THIS 400-FEET LONG 4-ZONE

MOORE SOFTBOARD DRYER

at the new Dierks Forests, Inc., Woodfiber Division Plant, Craig, Oklahoma, brings into existence for the industry

A NEW CONCEPT IN FIBERBOARD PRODUCTION

● We welcome the opportunity to give you specific information on this dryer or other items in our diversified line of drying and handling equipment for softboard, gypsum, hardboard, lumber and veneer.

FOUR FACTORIES WILL SERVE YOU:

MOORE METHODS

MOORE DRY KILN COMPANY

JACKSONVILLE FLORIDA | BRAMPTON ONTARIO | VANCOUVER BRITISH COLUMBIA | NORTH PORTLAND OREGON

CROSS SECTION

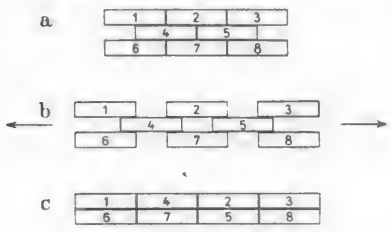
. . . Voice of Membership

Stress Relief

Gentlemen: At the FPRS meeting in Louisville, John Lutz presented my paper on "Drying Stresses in Veneer and Their Relief." The paper was subsequently published in the July issue of the *Journal*.

During the discussion, Steve Preston of the University of Michigan, raised the question: "What is the mechanism by which stresses are relieved?" The following is a hypothetical explanation of stress relief.

Between the particles of a solid substance act attracting and repulsive forces. In the stress free, unstrained state the particles are in normal distances from each other (fig. a), their attracting and repulsive forces are in equilibrium. In the tension stressed, stretched state (fig. b) the distance between the particles is increased, their attracting forces are now bigger than the repulsive forces; the difference of these two forces equals the outer tension force. Stress relief may take place in the stretched substance by particles sliding into a new neighborhood as illustrated in fig. c. Then the particles have again their normal distances from each other and the substance—though still stretched—is stress free. A corresponding example is possible for compression stresses.



This hypothesis works all right with metals. For wood, additional assumptions have to be made, because deformed wooden samples retain their original form as soon as they are boiled or steamed: the particles in wood—probably micelles—are always linked with their original neighbours. After a plastic deformation with position changes of micelles the links are pulling back into their original neighbourhood as soon as the piece of wood gets wet and hot.

HANS KUEBLER, Federal Research Station for Forestry and Forest Products, Reinbek, Germany

Pulp and Paper Scholarships

The Scholarship Committee of the Pulp and Paper Foundation, Inc., has awarded 55 scholarships with an aggregate value of $32,175 to students in the School of Forestry at North Carolina State College.

In announcing the awards, Prof. R. G. Hitchings, acting head of the college's pulp and paper technology program, said 22 scholarships went to new freshmen who will enroll in the pulp and paper technology curriculum in September and 33 scholarships for upperclassmen in the curriculum were renewed.

The chairman of the Pulp and Paper Foundation's Scholarship Committee, Dr. H. Y. Charbonnier of the Union Bag-Camp Corporation, Savannah, Ga., said that all states of the Southeast except one are represented by scholarship recipients—a fact which demonstrates the regional nature of the pulp and paper program at North Carolina State College.

Industrial Forestry Seminar

The College of Forestry of the University of Washington will cooperate with the Yale University School of Forestry in presenting the Seventeenth Yale Industrial Forestry Seminar at Seattle during the week October 23–27, 1961.

The Seminar will be on the topic "Financial Management of Large Forest Ownerships" and each of the 5 days will be devoted to a discussion of some phase of this topic under outstanding leaders in the field. Two of these men are Robert V. Hansberger, President of Boise Cascade Corporation, and John Fedkiw, Forest Economist at the Pacific Northwest Forest Experiment Station.

Enrollment in the Seminar is limited to twenty men whose experience will qualify them for participation. For additional information write to: Professor Z. W. White, Yale School of Forestry, 205 Prospect Street, New Haven 11, Conn.; or, Dean Gordon D. Marckworth, College of Forestry, University of Washington, Seattle 5, Washington.

COMING EVENTS

Sept. 13–14: Northern Hardwood and Pine Manufacturers Assn., Northland Hotel, Green Bay, Wis.

★

Sept. 13–15: Semi-annual Meetings, Western Pine Association, Multnomah Hotel, Portland, Ore.

★

Sept. 14–16: Annual Meeting, 16th Annual Lake States Logging Congress, Timber Producers Assn., Green Bay, Wis.

★

Sept. 16–19: Annual Convention, National Assn. Furniture Mfrs., Hilton Hotel, Chicago, Ill.

★

Sept. 17–20: Annual Convention, International Concatenated Order of Hoo-Hoo, Hotel Americana, Miami Beach, Fla.

★

Sept. 19–22: Forest Industries Equipment Exhibition, Central Canada Exhibition Grounds, Ottawa.

★

Sept. 22: FPRS Upper Mississippi Valley Fall Meeting, Research Center, Minnesota Mining & Manufacturing Co., St. Paul Minn.

★

Sept: FPRS Pacific Southwest Section Meeting, date and location to be announced.

★

Oct. 11–13: FPRS Mid-South Section Meeting, King Edward Hotel, Jackson, Miss.

★

Oct. 15–21: National Forest Products Week.

★

Oct. 16–17: FPRS Pacific Northwest Section Meeting, Qualicum Beach, Vancouver Island, B. C.

★

Oct. 19–20: Annual Fall Meeting, FPRS Midwest Section. Theme: Wood Composition Board, McCormick Place, Chicago, Ill.

★

Oct. 20: Annual Fall Meeting, FPRS Northern California Section, Fort Bragg, N. C.

★

Oct. 23–25: Annual Meeting Canadian Wood Development Council, Timberline Hotel, Banff, Alberta, Canada.

★

Oct. 27–28: FPRS Inland Empire Fall Meeting, Washington State University, Pullman, Wash.

★

Nov. 2–3: FPRS Northeast Section Fall Meeting, Hotel Prince George, New York City.

★

Nov. 2–3: Annual Fall Meeting, FPRS Carolinas–Chesapeake Section, Battery Park Hotel, Asheville, N. C.

OUR FOUR-POINT PROGRAM

For best utilization of America's timberlands

1. **Good management of our forests—by the most advanced tree-farming methods.**
2. **Products research to utilize to the fullest the timber we cut, so that nothing goes to waste.**
3. **Modern marketing and sales management to balance product demand against materials supply.**
4. **Consumer-oriented development of products to make sure that every product is planned to fill a known consumer need.**

A simple program—simply stated—but it requires vast investments in skilled manpower, lumbering facilities, forest management, research and development laboratories, and modern plants. And—to get the most effective distribution—widespread modern warehousing and sales operation to be sure that our forest products reach markets in every part of the country.

United States Plywood—40 years old, in 1959—is in business for the future as well as the present.

That is why you will find throughout our organization a dedication to those efforts which will make for the BEST UTILIZATION OF AMERICA'S TIMBERLANDS.

United States Plywood

55 West 44th Street, New York 36, New York

THERE'S A BORDEN GLUE
FOR EVERY JOB YOU DO

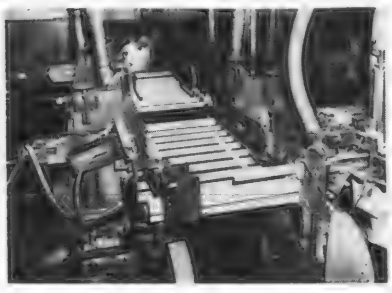
© The Borden Company

Plywood, glulams, flush doors, edge-gluing, furniture, whatever your adhesive problem—Borden's job-balanced adhesives keep your gluing department moving smoothly and profitably. Borden's adhesives are tailored by our laboratories to meet your specific job needs.

There's a Borden adhesive to do every job—hot press, cold press, RF gluing, plastic surfacing, assembly gluing, and metal to wood gluing. Plants in Bainbridge, N.Y., Demopolis, Ala., Fayetteville, N.C., and Browntown, Wis., are ready to supply you . . . *fast.* Don't just buy adhesives—buy Borden's! And Borden specialists can help you set up an adhesives program based on your specific needs.
Write The Borden Chemical Company, Resins and Chemicals Dept. FP-91, 350 Madison Avenue, New York 17, N.Y.

THE BORDEN CHEMICAL COMPANY ©TBC

NEW PRODUCTS and Literature



Brick Moulder

Automation engineering at work in a large window factory is found in a "brick moulder" setup designed to provide lineal and cross milling in sequence and automated production of right and left hand pieces correctly beveled and mitered in a continuous operation.

A moulder does the necessary lineal milling for window frame side casing mouldings. They pass from the moulder directly onto a special double-end cutoff machine. It makes a 6-degree sill bevel cut off both ends of each piece. The moulding is then turned 90 degrees and raised to a higher double-end cutoff. At this cut-off station a 45-degree miter cut is made alternately on right and left ends. Two air cylinders do the job of pushing the mouldings alternately against right and left bumpers to permit alternate right and left mitering. Thus, one machine produces both right-side casing mouldings and left-side casing mouldings.

The "brick moulding" set-up, engineered by Mereen-Johnson's automation engineering department, is located at Andersen Corporation, Bayport, Minn. For more information, write.

Circle Item 1.

Design Data Booklets

Two new publications entitled "Environment for Learning" and "Heavy Timber Construction for Industrial Buildings" are available from the Canadian Wood Development Council. A copy of the revised Wood Data Manual No. 2 on post and beam construction is also available. Design data for planks and beams has been extended in this booklet to include loadings of 50 pounds per square foot. Distribution of this publication is being limited to new requests. Single copies of all CWDC publications are available without charge, and bulk quantities may be ordered at a nominal price.

Circle Item 2.

Specifications for Pallets

The first comprehensive specification for softwood plywood pallets ever developed has just been published by the National Wooden Pallet Manufacturers Association, Washington, D. C., and the Douglas Fir Plywood Association, Tacoma, Washington. Entitled "Specifications for Douglas Fir and Western Softwood Plywood Pallets," the publication is meant specifically as an aid to those responsible for purchase of flat pallets and pallet containers built with softwood plywood.

The two national associations undertook the development of the highly detailed manual to establish a standard suitable throughout the pallet industry. The joint effort is an indication of the growing interest in plywood pallet construction.

The Specifications create two vertical, well-defined grades for plywood pallets and pallet containers. The grades are "custom" and "industrial." The Specifications are written so that buyers can compare quickly the differences in quality of the two grades. The Specifications are available by writing.

Circle Item 3.

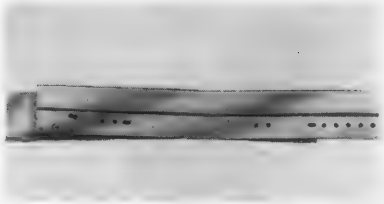
Lumber Drying Systems

Three different lumber drying systems are now available in the Standard Speed-Air line, according to an announcement from Standard Dry Kiln Company. Customers can select from the Low-Temp Drier, the Compartment Drier, and the Progressive Drier.

The Standard Speed-Air Low Temp Drier is designed for efficient, economical drying under low-temperature controlled conditions. It can also be used as a pre-drier in conjunction with kiln drying. The latter arrangement provides increased kiln capacity at moderate cost. Automatic controls regulate temperature and humidity conditions within the Low-Temp Drier. Direction of air flow is automatically reversed at pre-set intervals for maximum uniformity. Either steam or natural gas-fired systems can be used to heat air in the drying chamber.

The third Speed-Air System is called a Progressive Drier. It puts lumber air drying on a continuous "production line" basis. A battery of high-powered fans are mounted into the heavy steel frame doors which open on the green end to accept freshly sawed lumber. The lumber moves in stages from green to partially dry to air-dried, thus providing uninterrupted production. Complete details on all three Standard Speed-Air Drying Systems may be obtained.

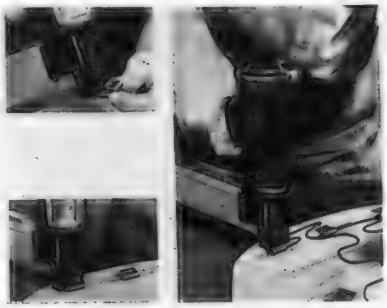
Circle Item 4.



New Drawer Slide

Design engineers at Grant Pulley & Hardware Corporation have developed a new, automatically closing drawer slide, called the No. 340 Auto-Slide. It includes all of the features customarily found in Grant Drawer Slides with the exclusive addition to the self-closing principle which enables a drawer to gently shut itself after the slightest push. According to a Grant spokesman, "The Auto-Slide is most suited for store fixture, millwork and kitchen cabinet application. Housewives and store clerks will find it a pleasure too, not to have to do more than flick a finger and watch the drawer close." Installation of the 340 Auto-Slide requires three simple steps. The slide requires only ½ inch at either side of the drawer and will support up to 100 pounds. The 340 Auto-Slide is available in lengths from 14 to 28 inches. Literature containing technical data and prices is available.

Circle Item 5.



Staples and Nailer

A new series of 16-gauge, 1-inch wide crown staples, and a Duo-Fast S-170 Staple Nailer to drive them will be one of the features of the exhibit put on by Fastener Corporation at the National Association of Furniture Manufacturers' Supply, Equipment and Fabric Fair.

The new staple and the S-170 are used for furniture crating where combination wood/corrugated shipping cartons are used. The extra wide crown of the staple eliminates tearing of the corrugated, replacing the nail/washer combination sometimes used. Designed to meet railroad shipping specifications, the staple is available in leg lengths of 15/32 inch to 1¼ inches. More information may be obtained.

Circle Item 6.

A Word About . . .

Carbide Saw And Cutter "RENTAL"

By

C. E. Drake

ON MY VISITS with our customers, they report that other carbide saw people are claiming that they have now greatly reduced their prices and at these new low prices they are competitive with Drake Rental Service.

This confession that their prices have been too high for years, was a long time coming, but they have a long way to go to be competitive with Drake Rental Service as to price and service.

Drake has always sold Carbide saws and cutters and our prices have always been available on request. Be sure to get Drake prices when you are considering the purchase of carbide tools.

Then compare price, compare Drake reputation for reliable performance and quality, and, above all, compare Drake service and the service cost.

We do make a confession also, that we have never been aggressive in selling carbide tools for the very simple reason that where there is very much usage of carbide tools, or a production operation of sawing or machining, a customer can not make ownership of carbide tools competitive in cost with our Rental service.

Do not make the awful mistake of thinking that because Drake rents carbide tools, that all makes of carbide tools are that good.

The next time you are told that it is cheaper to own your carbide tools, ask them if they will put all the tools you need in your plant, including the necessary spare tools for sensible change schedules to prevent tool abuse by operating too long between sharpenings, and give you three to four years to pay for them plus an absolute continuing guarantee on performance. You get this under Drake Rental System.

Then, without making any apology, demand of the supplier, a guarantee that the cost of tool replacement because of accidental damage, wearing out, carbide tip replacements, and sharpening, will not exceed the Hourly Service rates cost provided under Drake Service.

Today, many modern woodworking plants recognize that complete conversion to tungsten carbide tools is imperative cost wise and that the efficient usage of carbide tools is basically a service matter and must be considered purchase wise from that standpoint.

Drake does not merely invite comparison of costs, we insist on it, that's one of the chief reasons why there are so many plants today that are completely equipped with Drake tools and remain steadfast users of Drake Service through the years.

Nearly all of the other carbide saw people have tried imitation of Drake Rental Service during the past fifteen years.

Saw users who have visited Drake factories; seen the labor saving special machinery built by Drake to handle large production, insure uniform quality and control labor costs, know the reason for Drake's continuing success while others fail in their attempts to imitate or compete with our "Rental" Service.

Drake is the only Carbide Saw Company on earth that through its rental system furnishing all the tools for an operation, doing all the servicing, receiving complete meter recorded hours of production time, has all the facts at hand and knows what carbide tool costs really are and bases its charges to the customer accordingly.

For assured lowest overall cost Carbide tool service, get the facts from Drake.

DRAKE SAW CORPORATION
P. O. Box 8574, 3041 Lynch
Phone FLeetwood 4–1584
Jackson, Mississippi

DRAKE MEMPHIS SAW SERVICE
357 North Main Street
Memphis 3, Tennessee
Phone JAckson 6–1916

Drake Saws

PHONE Mission 5-3539

DRAKE CORPORATION

2723 IVANHOE AVENUE
ST. LOUIS 39, MO. U.S.A.

Commercial Standard Issued for Western Softwood Plywood

A printed edition of Commercial Standard CS122–60, *Western Softwood Plywood* is now available, according to the Commodity Standards Division, Office of Technical Services, Business and Defense Services Administration, U. S. Department of Commerce. This revision covers the principal grades of interior type, exterior type, and overlaid Western softwood plywood other than "Coast type" Douglas-fir, Western larch, and the Western pines. It also covers structural grades of red and white lauan hardwood plywood and the grades of red alder and Western poplar as commonly utilized by West Coast plywood manufacturers. Included are tests, standard sizes, size tolerances, marking and certification, and nomenclature and definitions. Copies may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 15 cents.

Drake Saw Corp. Installs Pay-As-You-Use System

The Drake Saw Corp. has inaugurated a plan whereby small plants may acquire carbide-tipped saws and pay only for the actual time they are used.

The new plan eliminates much of the large investment in saw equipment required of the small plant, and it insures continuing tool service and engineering help from Drake.

Economy for saw users is demonstrated by the fact that Drake does not receive an amount equal to the value of the saws until they have been used 6,000 hours—from 3 to 4 years in most small plants.

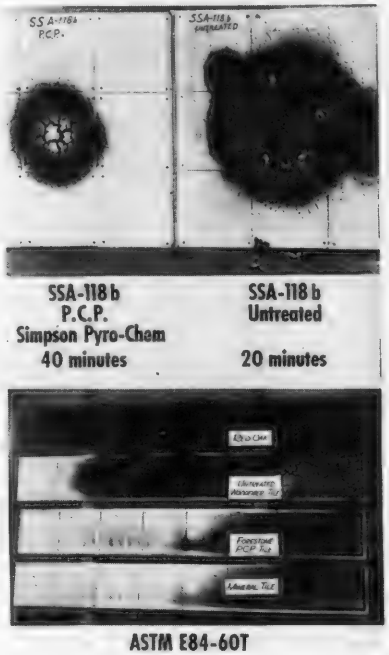
The Drake Saw Corp., with plants in St. Louis, Mo., Memphis, Tenn., and Jackson, Miss., also manufactures a turret profile grinder, moulding and forming tooth cutters and cutter heads, dados, finger jointers, and carbide-tipped multi-piece tenon heads.

Additional information is available.

Circle Item 7.

Flame-Spread Rating for New Simpson Woodfiber Tile Is as Low as Ratings for Incombustible Materials

Model displays the four Forestone textures and two perforated patterns available with Pyro-Chem protection.



Above are laboratory tests showing results of woodfiber acoustical ceiling tile treated with Simpson Timber Company's new exclusive Pyro-Chem process.

A scientific process that gives Simpson woodfiber acoustical ceiling tile flame-spread ratings comparable to incombustible mineral tile has been announced by Simpson Timber Company.

Called Pyro-Chem, the exclusive Simpson process impregnates every woodfiber with fire-proofing chemicals. Pyro-Chem Protection will be available in the complete line of Simpson Forestone textures and two perforated patterns.

For the first time it will be possible to select the specific combination of fire safety, economy, noise control, beauty and ceiling texture required for each acoustical installation. Simpson PCP acoustical will cost approximately one-third less than incombustible tile and only a few cents more per foot than ordinary woodfiber tile.

This combination of fire protection, woodfiber economy and effective sound control makes possible great savings in construction of schools, hospitals, clinics, churches, stores, restaurants and multi-story buildings.

In tests conducted according to ASTM E84–60T, by a leading independent research institute, Simpson PCP woodfiber tile scored some flame-spread ratings as low as 13. All Forestone textures and perforated patterns tested were within the 0–25 flame-spread range required for Type I material by leading municipal codes as well as uniform codes of the Building Officials Conference of America and the International Building Officials Conference.

This process is the second major acoustical development announced by Simpson in less than a decade. In 1955 Simpson introduced Forestone, the first fissured woodfiber acoustical tile. In recent years the Company has added other deep fissured textured patterns to its Forestone line. PCP marks the most important advancement in fire safety ever made in woodfiber acoustical materials.

Further information may be obtained.

Circle Item 9.

Testing Equipment

A new bulletin is available listing the optical as well as the physical test instruments manufactured by Gardner Laboratory, Inc., and an announcement of a new general catalog which will list a complete line of instruments and apparatus manufactured and sold by Gardner Laboratory, Inc. Copies of this bulletin may be obtained.

Circle Item 8.

Respiratory Protection

A bulletin describing the interchangeable respiratory protection provided with the M-S-A Dustfoe and M-S-A Gasfoe has been released by Mine Safety Appliances Company, Pittsburgh. The four-page illustrated folder shows how one facepiece can be used with a variety of filters and chemical cartridges to protect against dust concentrations, radioactive particulate, metal fumes, organic vapors, acid gases, ammonia, and other airborne hazards.

Details are provided on the Dustfoe 66 with replaceable electrostatic filter; the M-S-A Dustfoe Facepiece featuring the Type "H" Ultra-Filter; and the M-S-A Gasfoe with four interchangeable chemical cartridges. Both models use the same anodized aluminum facepiece. Copies of the bulletin are available.

Circle Item 10.

Mann-Russell
Model 700
Generator
20 kw output

All types of ELECTRONIC GLUING EQUIPMENT

Standard or Custom-Designed

MANN-RUSSELL engineers are specialists in the design, installation, and servicing of ELECTRONIC GLUING equipment for the wood industry. They can help you increase production; cut costs.

- Lumber Edge Gluers (Batch or Continuous Type)
- Veneer Edge Gluers
- Plywood Panel Patchers
- Plywood Scarf Gluers
- Particle Board Scarf or Edge Gluers
- Lumber Scarf Gluers
- Lumber Finger-End Joint Gluers (Continuous Feed)
- Shingle Edge Gluers
- Shake Panel Gluers
- Laminated Roof Decking Gluers
- Timber Laminators

and . . .

- Veneer Moisture Detectors (Continuous Flow)
- Special-Type Lumber Moisture Detectors

Special equipment engineered to your needs and specs.

Mann-Russell Electronics INC.

1401 Thorne Road, Tacoma 2, Washington
Phone: FUlton 3–1591

Bandsaw Cutting Shear and Clamp

A new bandsaw cutting shear, developed by Stryco Manufacturing Company, San Francisco, cuts up to 2-inch widths and is provided with replaceable tool steel blades. Mounted on a bench, this compact and sturdy accessory makes square cuts without crimping or bending and insures correct matching of blade ends in the welding machine for perfect alignment.

A new foot operated clamp for holding bandsaw blades while dressing off a newly complete weld has also been introduced. This very practical accessory is of particular interest to saw shops, supply houses and maintenance departments. The filing clamp is quick acting and of heavy duty construction. It holds band saw blades up to 2-inch width while the extruded metal is filed from the welded joint. Only a light foot pressure is required to open the clamp for insertion or removal. Information on these two products may be obtained.

Circle Item 11.

New Molded Wood Product

The Plastics Division of the Gisholt Machine Company, Madison, Wis., is proud to announce a new development in plastic molding. Chipform, a molded wood product is undergoing initial production runs. Angles, compound curvatures, varying wall thicknesses and the imbedding of inserts or fasteners is now possible in a high strength molded wood material.

Early indications of market acceptability lie in the following areas: bowling alley equipment, furniture seating and component parts, wooden casket sections, boat components, farm equipment, and the automotive industry.

Chipform currently requires a surface finishing operation wherever a completely smooth finish is mandatory. By sanding, filling, and painting or any other wood finishing process a high gloss surface is obtainable. More information is obtainable.

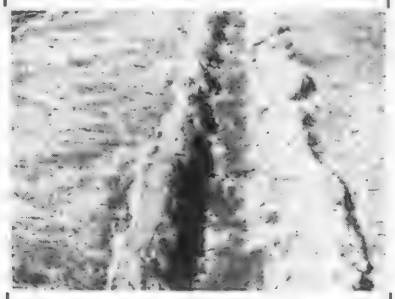
Circle Item 13.

BETTER SURVIVAL, BETTER GROWTH

WITH

ROOTSPRED

TREE PLANTERS



ROOTSPRED "Lake States". Simultaneous scalping and planting.

Non-Clogging Scalper.

Planter is for a three point lift tractor.

ROOTSPREDS are way ahead with Christmas Tree Growers.

For specifications, prices, photos, write:

ROOTSPRED

St. Petersburg Pennsylvania

Guide for Fire-Retardants

A completely new guide covering fire-retardant treatments of building materials has just been issued by the National Fire Protection Association.

This is the first standard on methods of reducing flame spread properties of building materials. It deals with both pressure impregnation and the use of surface coatings like fire-retardant paints.

Work on development of this NFPA standard, one of more than 185 issued by the international fire safety organization, began in 1957 with consideration of treatments for the flameproofing of wood. The subject was subsequently expanded to include fire-retardant treatments for all building materials.

The standard was developed by the NFPA Committee on Flameproofing and Preservative Treatments chairmanned by D. P. Skaer of the Cook County Inspection Bureau, Chicago. It was adopted at the Association's recent annual meeting in Detroit.

Copies of the Standard for Fire-Retardant Treatments of Building Materials (NFPA No. 703, 6 pages, 40 cents) are available from the National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass.

Circle Item 12.

Award-Winning Package Presents Band Saw Data

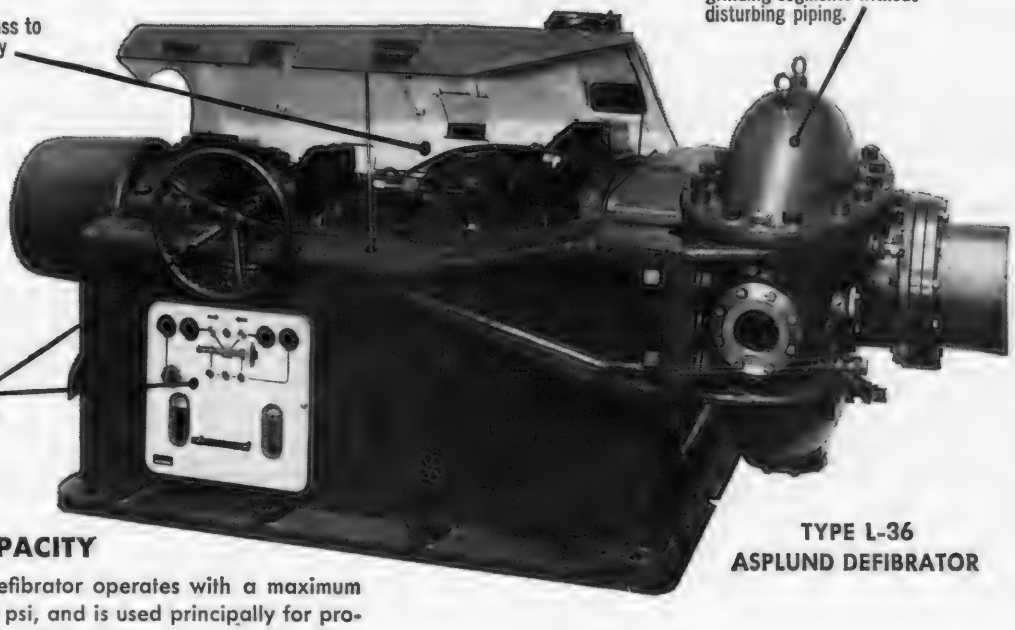
Helpful information to obtain greater efficiency in metal band sawing is imprinted on band saw blade packages by the Disston Division of H. K. Porter Company, Inc., Pittsburgh. A guide also is given for selecting blade speeds and teeth-per-inch for cutting ferrous and nonferrous metals, various plastics, wood, pulp materials, and miscellaneous other materials. The carton, printed in four colors, won a merit award for "general merchandising superiority" in the hardware category of the 1961 Folding Carton Competition conducted by the Folding Paper Box Association. Two sizes of Disston metal cutting band saw cartons are shown in this photo. All sizes are imprinted with the same information.

Circle Item 14.

FOR CONTINUOUS PULPING, THE NEW *Asplund* L-36 DEFIBRATOR

offers

- Close control of grade and uniformity of pulp
- Precise adjustments easily made with hydraulic controls
- Continuous service with low maintenance


Top section of housing can be removed for replacement of grinding segments without disturbing piping.
Cover lifts for easy access to hydraulic system for easy setting.
Control station with graphic panel and centralized controls for regulating grinding pressure.

TYPE L-36
ASPLUND DEFIBRATOR

SERVICE and CAPACITY

The L-36 ASPLUND Defibrator operates with a maximum steam pressure of 180 psi, and is used principally for producing fiber for hardboard, insulating board, and roofing felt. It is conservatively rated at 80 tons of hardboard fiber per day. It is also used for semi-chemical pulping and asphalt dispersion with capacity up to 150 tons per day. The size of the Defibrator motor in either case is between 400-600 HP.

CONSTRUCTION

Solidly built for continuous heavy duty service, with double acting thrust bearings and one radial bearing, all lubricated through a circulating oil system by means of a pumping unit with safety controls. Two 36" discs, one rotary and one stationary have replaceable segments; segment holders, housing, and top cover are all stainless steel. The shaft in the main stuffing box is protected from wear by a stellited sleeve.

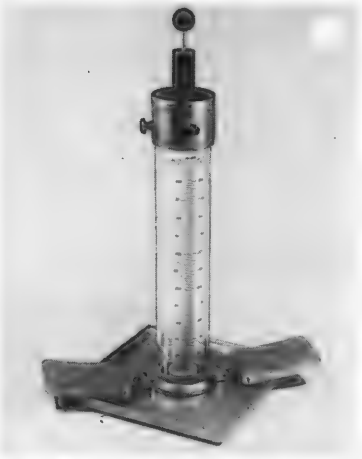
RELATED EQUIPMENT

Rotary feeders, screw feeders, and digester units are available for use with existing equipment, or coordinated for use with the L-36 ASPLUND Defibrator. Size of feeders and digester units depends on the type of process, the volume to be handled, and the capacity required.

FACTS and FIGURES

When you are planning to add pulping facilities or to modernize, we will be glad to work with you in detail, toward layout and equipment best suited to your requirements.

AMERICAN DEFIBRATOR, INC. CHRYSLER BUILDING NEW YORK 17, N. Y. West Coast: A. H. Lundberg Mercer Island, Washington



Soil Density Measurements

The TESTlab Corporation announces the availability of a device called the VoluTESTer which is used to measure the density of soil in the field by accurately measuring the volume of a hole using the so-called balloon density method. This method consists of completely filling a hole by pumping water into a balloon which closely conforms to the contour of the hole. The amount of water necessary to fill the balloon is measured on a graduated cylinder.

New features found only on the VoluTESTer Model I are a set of outriggers for the operator to kneel on to hold the unit down while exerting pressure; an unbreakable graduated plastic cylinder; a bicycle-type pump; a pressure equalizing relief valve.

The TESTlab Corporation also has available a lower-priced balloon density apparatus called the VoluTESTer Model VI. This model does not incorporate the features listed and is offered to those who want to make balloon density measurements without investing a great deal of money. Write for more information.

Circle Item 15.

U. S. Plywood Now Selling Fiberglass

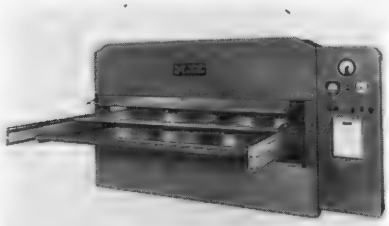
The newest addition to United States Plywood Corporation's extensive line of building materials is fiberglass paneling and accessory items. The new Weldwood fiberglass panels come in three grades: superior, structural and economy, according to M. W. Pollack, vice president in charge of sales. A host of applications is cited and includes room dividers, carports, movable screens, table tops, shelves, kitchen carts, shower stalls, skylights and breezeways.

The superior grade is 6 ounces per square foot with a .045-inch thickness. It has a glass fiber content of 1½ ounces per square foot and uses the exclusive 20 percent Acrylic Modified Rohm and Haas Company P444 resin formula. The structural grade is eight ounces per square foot and is 1/16 inch thick. Its properties are similar to the superior grade except for its heavier weight and two-ounce per square foot glass fiber content.

The two grades are priced competitively with other polyester paneling of the same weight and are priced lower than comparable acrylic panels.

The company is offering instructions on how to build patios and carports with Weldwood fiberglass paneling in Brochure ♯2220, available at all branch office sales centers or by writing.

Circle Item 16.



Shuttle Loading Presses

Yates-American, Beloit, Wisconsin, announced the addition of the Model SPA-200 Automatic Shuttle Loading Presses to their line of woodworking machinery. This is the result of a recent agreement with H. Schubert Ltd., London, England. The Model SPA-200 Press, built to the highest machine tool standards and Yates-American specifications, is a low investment machine with an unusual combination of design features that provide broad versatility, faster production, and reduced floor space requirements. Complete service including engineering counsel, stock machines, factory trained service engineers, and large stock of replacement parts is provided by Yates-American through their main plant in Beloit and branch offices in Atlanta, Georgia, and Portland, Oregon.

Equipped with one fixed and two moving platens, the Model SPA-200 Press was especially designed to accommodate jobs where production is governed by lay-up time rather than pressing time. Laying-up is in progress on one platen while the other is under pressure, providing continuous production. Arranged with a fully automatic cycle, the machine is started by push button and continues to operate until the present pressing cycle is completed. Then the machine opens automatically for shuttle loading of the prepared moving platen and the next pressing cycle. Cycle time is infinitely adjustable from 0 to 30 minutes. Write for more information.

Circle Item 17.

Chipper Knives

A complete line of high quality chipper knives that are available in sizes from 9 to 36 inches long, and in widths and thicknesses to customer specification, has been developed for the pulp and paper industry by the Machine Knife Division of United Shoe Machinery Corporation.

The new knives are made of an ultra-high quality alloy steel that is heat-treated to insure a maximum impact capability with minimum embrittlement and spalling. They are available with various fork and loop combinations, and to required hardnesses within a recommended range. Each knife is coded, written records being kept of its manufacturing and process history. User tests in mills from Maine to Georgia have indicated superior life and performance between grinds on hard woods, soft woods, and combinations of these, including logs in the frozen and "catface" conditions. Write for more information.

Circle Item 18.

Epoxy-Metal Compound

Development of a new versatile super-strength epoxy-metal compound specially designed to fill, bond, and repair steel, iron, aluminum, bronze, brass, lead, tiles, concrete, brick, marble, ceramics, porcelain, wood, glass, leather, fabrics, and most hard plastics has been announced by the Consumer Products Department of The Borden Chemical Company.

The compound works equally well in repairing dents in sheet metal, defects in metal castings and patterns; caulking metal seams in casements, ducts, and tanks; sealing automobile radiators and plumbing fixtures; patching holes in automobile bodies; anchoring bolts and screws; and as a covering for countersunk bolt and rivet heads.

Called "Elmer's All-Purpose Epoxy Metal Compound," the new product is a two-part system consisting of metal-filled resin and hardener. Available in half-pint, pint, quart, gallon, and larger size units, distribution is planned through the hardware wholesaler trade.

Circle Item 19.

Why the *strongest* molded-wood articles so often have Durez resins in them

Whack . . . but no crack! When you see a molded-wood product that's *extra strong*, you can be pretty sure it's bonded with phenolic resin.

Why? Because phenolics give strength and durability few other resins can. That's an important point to consider—whether you're making croquet balls, toilet seats, or core stock.

Low moisture absorption and *heat resistance* are two additional good reasons for thinking about phenolic. If moisture and heat are warping the quality of your product, a switch to stable phenolic resins may be the answer.

If you're like a great many phenolic users, you'll specify a *Durez* phenolic. You'll find you can count on uniformity, drum to drum and month to month —because Durez makes its own raw materials and so can control quality tightly.

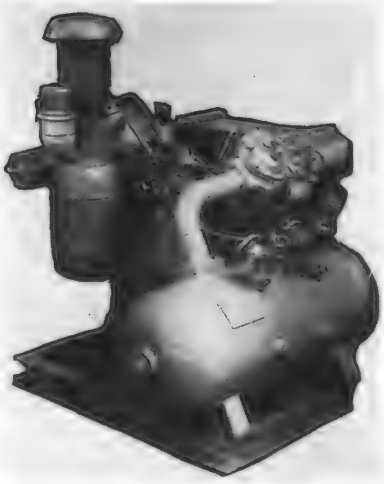
You'll avoid many processing headaches by taking advantage of Durez technical help. It brings 38 years of resin development and molding application into your plant without a penny of extra cost. If you'd like more information on Durez resins for bonding wood particles, just drop us a note.

DUREZ PLASTICS DIVISION

9909 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS



Vehicle Mounted Compressor

Market introduction of a new 21 horsepower vehicle mounted air compressor delivering 78 cubic feet of air per minute was announced today by Atlas Copco, Inc. This compressor, designed to draw its power supply from the vehicle engine, is a two cylinder, two stage, single acting, air-cooled, V-type machine with intercooling between stages. It is easy to operate and equipped with a steel frame for bolting to the vehicle. This compressor is intended for rear mounting to the Willys Jeep CJ-5 and CJ-6 as well as for center mounting to the FC-150 and FC-170. Write for more information.

Circle Item 20.

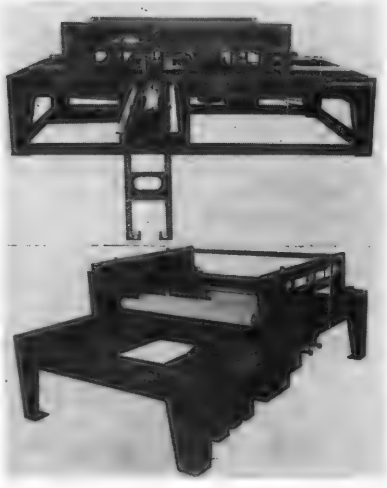
New 840 HP Tractor on Rubber

The latest entry in the drawbar derby is an 840 horsepower tractor on rubber tires which is intended to supplant tandem pushers for loading big-capacity scrapers, announces R. G, Le Tourneau, Inc. The big diesel-electric machine is designated a Series K–103 "Pacemaker" Tractor—a new trade name for Electric Wheel earthmoving equipment manufactured by R. G. LeTourneau, Inc.

Two diesel-electric generating plants supply power for three Electric Wheels on the Series K–103. This electric drive combination develops over 90,000 pounds of drawbar pull, measured dynamically, according to the manufacturer.

Dimensions are 42 feet long by 15 feet wide by 16 feet high. These encompass an unusual design. The tractor is built like a tricycle with two wheels forward and a single wheel (which steers) at the rear. Wheels are individually powered, each with its own DC motor and gearing built inside the hub. Changing polarity of the applied voltage changes the drive from forward to reverse, with the same power and speed available for either direction of travel. Literature describing the Series K–103 Pacemaker Tractor may be obtained.

Circle Item 21.



Heavy Duty Plywood Equipment

Kvalheim Machinery Company has developed an extra heavy duty line of equipment especially for the plywood industry. Among the two machines now available in this line are the Model 2.4.1 and the Model T1–11. A heavy duty double end tenoner will also be available soon.

The KVAL Model 2.4.1 is used for edge patterns in plywood. It has a total of 8 feed rolls for positive directional feed through the machine. In front of the cutter heads, there is an adjustable system of short rolls to hold the plywood positively at the cutting point. The Model T1–11 has a $3\frac{15}{16}$ diameter shaft in addition to the side cutter units. This makes it possible to cut both edge patterns and surface patterns with this machine. One feature of the Model T1–11 is its special shaft removal system. An auxiliary track is screwed to the side of the machine. The shaft is lowered onto a yoke carriage. By removing the belt and unscrewing the pillow block bearings, the whole assembly may be rolled out of the machine. Further information may be obtained.

Circle Item 22.

New Bulletin Available on Conveying Wood Products

The Chain Belt Company, Milwaukee, Wis., and a supporting member of FPRS, recently issued a new bulletin that describes conveying, elevating, and power transmission equipment made by Chain Belt for the forest products industries.

The 43-page bulletin is profusely illustrated with photos, flow charts, and tables of specifications. Some of the subjects covered are sawmill conveyors—from the log deck to the stacker machine; systems for the planing mill—from the kiln to the reloading of finished lumber; chip plant conveyors; pulp mill conveyors —from log to digesters; and complete systems for softboard, hardboard, and plywood plants.

Individual phases of these materials handling techniques that receive special emphasis are log decks, saw carriages, edgers, trimmers, and sorters, kiln loading and discharge, debarking, chip storage, and the handling of refuse, sawdust, and bark.

Another publication available from Chain Belt, is REX World, a pictorial news bulletin issued several times a year. The latest issue, which went to press shortly after FPRS 15th Annual Meeting at Louisville, contains several stories that should be of particular interest to FPRS members.

For example, a conveyor system and flume recently installed at Masonite's new plant at Laurel, Miss., is described. The system carries the logs from the arriving box cars to the chippers. A unique feature is that water in the 12-foot wide by 7-foot deep flume is cleansed by sand collectors and traveling water screens so that it can be used over and over again without troublesome debris problems. Masonite figures the system saves approximately $16,000 a year, and it has reduced labor requirements from 32 men for three shifts to 12 men for two shifts.

A second story describes an automated lumber sorter that has cut labor requirements on the green chain to the point where sorting is a 1- or 2-man operation.

Developed by Production Systems, Inc., Seattle, the brain of this system is a magnetic memory unit developed by Republic Electric and Development Co:, Seattle. The chains, sprockets, and power transmission operations were made by Chain Belt.

Copies of both these publications are available on request.

Circle Item 23.

ALE · HIGH POINT · SHAWANO · WEST MEMPHIS · KITCHENER · LA CHUTE · LANSDALE · HIGH POINT · SHAWANO · WEST MEMPHIS · KITCHENER · LA CHUTE · LANSD

The MARK of America's Finest Wood Glues

This Trade Mark is a familiar one to American Wood Workers for it identifies wood glues that have attained a standard of excellence often imitated but never duplicated.

Backed by almost 60 years of wood gluing experience and the most outstanding Gluing Service staff ever assembled in the industry, Perkins Glues are known to be consistently uniform in quality and dependability.

The result is that a Perkins Glued product is always a better product.

PERKINS GLUE COMPANY
Lansdale, Pennsylvania

Three-Stage Belt Sander

A new 4-page bulletin illustrates and describes the new Model S-25 Belt Sander recently announced by Yates–American, Beloit, Wisconsin. This is a high production machine that combines fast stock removal with the finest finishes. Three-stage sanding is completed with one machine in one pass . . . and at feed rates up to 60 F.P.M. The first two belts bring the stock to selected thickness before it reaches the third-belt position. A minimum of stock is removed by the last belt, providing a superior finish. Combining operations in this way results in production rates over three times faster than the conventional drum sander. Reduced capital investment in equipment, increased operator productivity, and simplification of work handling results in up to 50 percent savings in sanding costs.

Outstanding features include: automatic belt tracking mechanism, infinitely variable feed adjustment from 20 to 60 F.P.M., precision screw-operated depth of cut adjustment, handwheel adjustment of traveling bed to accommodate thicknesses to 3 inches, and engineered exhaust system. The Model S-25 accommodates widths up to 24 inches. Free copy of bulletin available on request.

Circle Item 24.

Solid State Remote Alarm

A solid state low-cost remote alarm monitor has been announced by CompuDyne Corporation. Called the "Alertra" Model 901, the device samples and encodes any number of data points and keys a single channel of any transmission medium. At the receiver, the signal is decoded and displayed. Operation is continuous.

The Model 901 is suitable for operation over microwave, UHF, VHF, or any grade telephone line. Circuitry is completely transistorized. The construction is resistant to moisture, fungus, and high temperature. By adding packages, any number of points can be monitored.

At the transmitter, switch closures or excessive voltage levels are detected and coded for transmission by PDM/NRZ Code. This coded information is keyed over the transmission medium. At the receiver the code is converted to "yes"/"no" information and is displayed as alarm conditions at a panel board. Contacts for print out or control sequencing can be furnished. Facilities for line and circuit test are included. A bulletin with more information is available.

Circle Item 25.

What's New in *Technical Publications*

Single Copies of the Following Reports are Available Free Upon Request from the Director, U. S. Forest Products Laboratory, Madison 5, Wis.

A durable natural finish that retains much of the beauty of wood house siding is described in one of 15 new or revised reports recently issued by the U. S. Forest Products Laboratory.

Properties, formulations, and methods of applying the finish, which protects siding exposed to weathering, are described in **Report 2096,** "Forest Products Laboratory Natural Finish." Since its introduction by the Forest Products Laboratory several years ago, the finish has been widely produced by paint manufacturers. The revised report brings up-to-date the experience records on it.

Three reports contain information concerning wood preservation. An investigation of wetwood—zones of wood in the tree that are wetter than usual—and the weekly parasitic bacteria associated with it is the subject of **Report 2215,** "Wetwood, Bacteria, and Increased pH in Trees." **Report** 2218, "Relative Aeration Requirements by Soft Rot and Basidiomycete Wood-Destroying Fungi,' describes the different growth responses of soft rot, imperfect fungi, and decay fungi when oxygen is severely limited within culture tubes.

The high tolerance of brown rot fungi to copper sulfate, and consequently to copper naphthenate, a fence-post preservative, is discussed in **Report 2223,** "Copper Tolerance of Some Wood-Rotting Fungi." This report is the result of research in which the preservative was shown to be effective only against white rot fungi.

Various uses for wood residues are described in three other research reports. In **Report 2224,** "Wood—A Source of Raw Material for Chemical Utilization," the carbohydrate and lignin in low-value wood were found to be important sources of chemicals. Chemical utilization would involve broken stem residues, limbs, veneer clippings, and sawdust.

Another use for these residues would be for board materials, as described in **Report 1666–21,** "Board Materials from Wood Residues." Such residues may also be burned as fuel. **Report 1666–18,** "Wood Fuel Combustion Practice," contains information about different types of wood fuels and descriptions of newly developed industrial furnaces for wood-burning.

Pulp industry technical experts will find special interest in three reports that discuss different wood species and varying conditions in pulping experiments. Second-growth Douglas-fir and red alder are only a few of the Pacific Northwest wood species found to be suitable for the manufacture of printing paper. Other species are discussed in "Suitability of Some Pacific Coast Woods for Printing Papers," **Report 2200.** Experiments with groundwood pulp are the basis of **Report 2220,** "Effect of Condition and Kind of Wood on Groundwood Pulp Quality," and **Report 2217,** "Pulping and Papermaking Experiments on Certain Pines of Mexico and Central America."

Making veneer from tamarack logs, which contain small tight knots, is discussed in **Report 1766–16,** "Veneer Cutting and Drying Properties."

Sawmill operators lose money in producing hardwood lumber if they ignore the position of external log defects. **Report 2221,** "Effect of Defect Placement and Taper Setout on Lumber Grade Yields When Sawing Hardwood Logs," describes and evaluates various sawing methods.

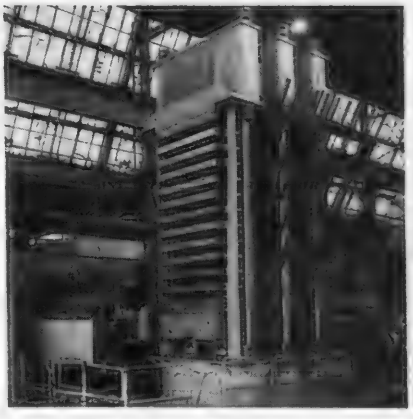
"Special Methods of Seasoning Wood," **Report R1665–2,** discusses drying wood by using hot acetone, a chemical used to remove "pitch" from pine knots. The water boils off, and after the acetone is removed, the wood is seasoned in one-half to one-fourth the time required for kiln drying.

Complete forming and pressing equipment for your new board plant

Whether you are considering a new board plant, or expansion or modernization of existing facilities, Washington forming and pressing equipment has a place in your plans for reliable, efficient and economical board production.

Washington personnel work closely with plant design engineers from the start, to design and manufacture for particle board and dry process hardboard—forming machine, shave-off, precompressor, flying and trim saws, speed changer, mating station, automatic loader and unloader, multiplaten press, board separator and complete conveyor systems, all custom-engineered for the individual installation.

Follow the example of the world's leading producers of hardboard, flakeboard, particle board and plywood—specify Washington equipment for automatic production. For complete information, contact Washington Iron Works, 1500 Sixth Avenue South, Seattle 4, Washington.



The 3,350-ton, 12-opening, 76" x 130" Washington press, shown above during final assembly and testing, is equipped with stepless control of timing, pressure and board caliper, to permit automatic cycle production of softboard, composition board and hardboard. Patented Washington features include simultaneous-closing, counter-balanced platens with temperature-compensated platen guides.

HOT PLATE PRESSES • PULP BALING PRESSES
SPECIAL HYDRAULIC PRESSES • AUTOMATIC PRESS LOADERS AND UNLOADERS
COMPLETE PARTICLE BOARD AND DRY PROCESS HARDBOARD
FORMING LINE EQUIPMENT

WASHINGTON IRON WORKS

WASHINGTON PRESSES

and ACCESSORY EQUIPMENT

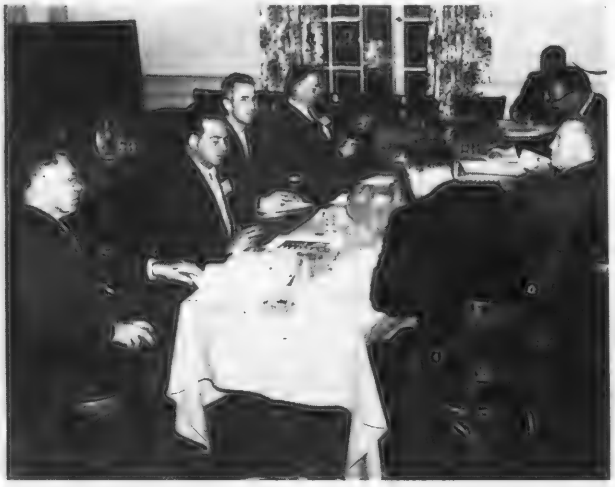
Annual meeting---

PRESS CONFERENCE: D. K. Saunders, R. H. Berry, Lt. Governor Wilson Wyatt, Chief Forester Harrod Newland, Kentucky.

If you regret missing this year's meeting, these reflections will give you a hint of its flavor to persuade you to be in Spokane in '62.

The men find themselves back to school, in a sense, in a meeting devoted to work.

"BEST PAPER in history of FPRS," said one reviewer of "Architecture of Cellulose," by Dr. Mary L. Rollins.



PLANS WERE formulated for a stronger FPRS Education Committee (above).

PRESIDENT D. K. Saunders, past president R. H. Berry, and general chairman Carl Trinkle preside at authors breakfast (right).

business & pleasure

For both men and wives, the meeting is a reunion with friends who, despite infrequent association, have become surprisingly close.

FIRST LADIES OF FPRS: Left to right—Mrs. K. E. Huddleston, Mrs. R. H. Berry, Mrs. D. K. Saunders, Mrs. J. L. Love, Mrs. W. R. Smith, Miss Elizabeth Davenport, Miss Harrar, and Mrs. E. S. Harrar.

R. H. BERRY was commissioned a Kentucky Colonel by Governor Wilson Wyatt.

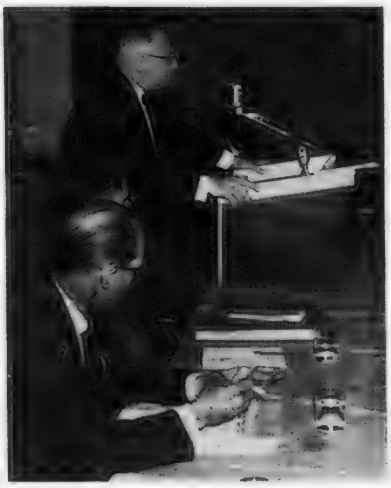
Despite the informal atmosphere, talk seldom strays from the field of wood and its allied activities.

EXECUTIVE BOARD and guests enjoy FPRS Official Luncheon.

You will return home filled with answers to your problems. But more important, you will have a number of intriguing new ideas generated during the free and informal face-to-face discussions.

PAUL HELLER, R. O. Woodfin, Charles McMillen, Eugene Landt, and William Huxter, convene on Mechanical Conversion.

CHAIRMAN R. L. Youngs confers with authors Arno Schniewind, W. L. James, R. E. Pentoney, and R. W. Davidson.



"PRODUCT DEVELOPMENT is the foundation of the forest products industry," said keynote speaker C. B. Dosker.

V. C. Hogren, C. B. Dosker, G. M. Hunt, winner of the Hitchcock Award, and A. B. Hood.

FPRS LADIES were entertained at brunch.

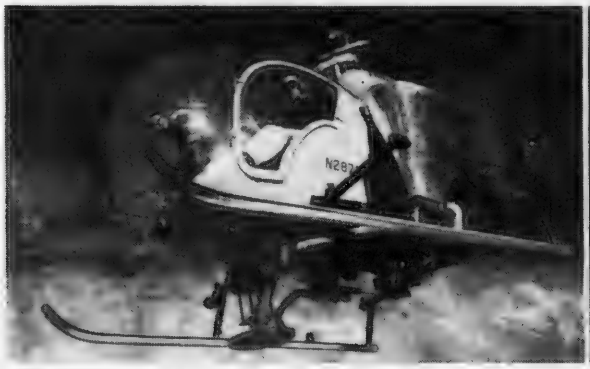
PROGRESS REPORT FROM POTLATCH

How research promotes utilization and forest management

By fortifying ground bark with balanced soil nutrients, POTLATCH has developed a combination fertilizer-mulch-soil conditioner. This new product is an excellent example of more complete utilization of the harvested tree.

Another first at POTLATCH . . . a new "high barrier" paperboard product produced in commercial quantities. Used for food cartons, this product has a thin coating of polyvinylidene chloride for maximum protection of food and improved printability for display.

One and one make one! That's POTLATCH Plylumber Flooring, a laminated combination of flooring and sub-flooring. All the work of fitting individual strips of flooring has been done at the factory. Plylumber Flooring is one of many wood specialty products developed at PFI.



POTLATCH foresters take to the air in helicopters! Even in inaccessible "burn" areas, reseeding is accomplished with speed and efficiency. Seeds dropped today will be the resource heritage left to generations yet unborn.

This PFI forester is using a Prism, a device for determining which trees are to be included in a timber inventory. Such equipment and techniques help the forestry staff obtain the detailed information which results in improved forestry practices.

PR-098

POTLATCH FORESTS, INC.

GENERAL OFFICES, LEWISTON, IDAHO

pfi

symbol of quality since 1906

SALES OFFICES: Kansas City, Mo., Elizabeth, N. J., Pittsburgh, Pa., Warren, Ark., Chicago, Ill., Lewiston, Idaho, Deer Park, Wash.

Wesley Loos, Tom Smeal, Ralph Bescher, Richard Hug, and Ray Rietz formed Treatments and Coatings Session.

You are certain to return home feeling that you have put in an intensive week, convinced that your time and efforts were well-rewarded.

D. K. Saunders

Dr. Fred Wangaard presides at session on Anatomy and Fundamental Properties.

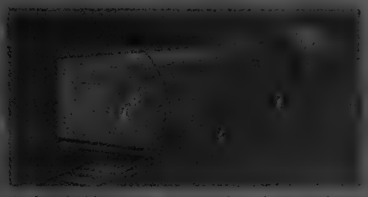
Below, left, J. J. Allegretti presides at enthusiastic meeting of Division of Production Management. Right, guests at FPRS Official Luncheon.

Mrs. R. H. Berry and Mrs. D. K. Saunders.

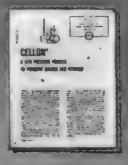
CELLON* PRESSURE-TREATED WOOD

A NEW KIND OF WOOD, PLYWOOD AND LUMBER/WITH PROPERTIES AND USEFULNESS NEVER BEFORE AVAILABLE

"Cellon," a new trademark of Koppers Company, Inc., is the brand name for a uniquely different, pressure-treated wood that is termite and decay resistant. In addition, Cellon pressure-treated wood has all of the properties and appearance of untreated wood—it is water repellent, free of raised grain, completely paintable and dimensionally stable. The preservative provides protection against decay and insect attack, is essentially non-water soluble, and can be applied either before or after fabrication without affecting size, weight or appearance. Typical uses include railroad car decking and roof planking, stadium structures and seating, boat decking and ribbing, furniture and formed shapes and countless other applications.



Dry preservative crystals are deposited deep within and through wood fibers in special pressure cylinders. Treated wood meets Federal Specification TT-W-00571g for insect and decay resistance.



FOR DETAILED INFORMATION—WRITE FOR BULLETIN W-392. It contains basic data on this new and unique kind of lumber, plywood and glulam and details properties which are important to know for the uses you may have in mind for Cellon pressure-treated wood.

CELLON

WOOD PRESERVING DIVISION

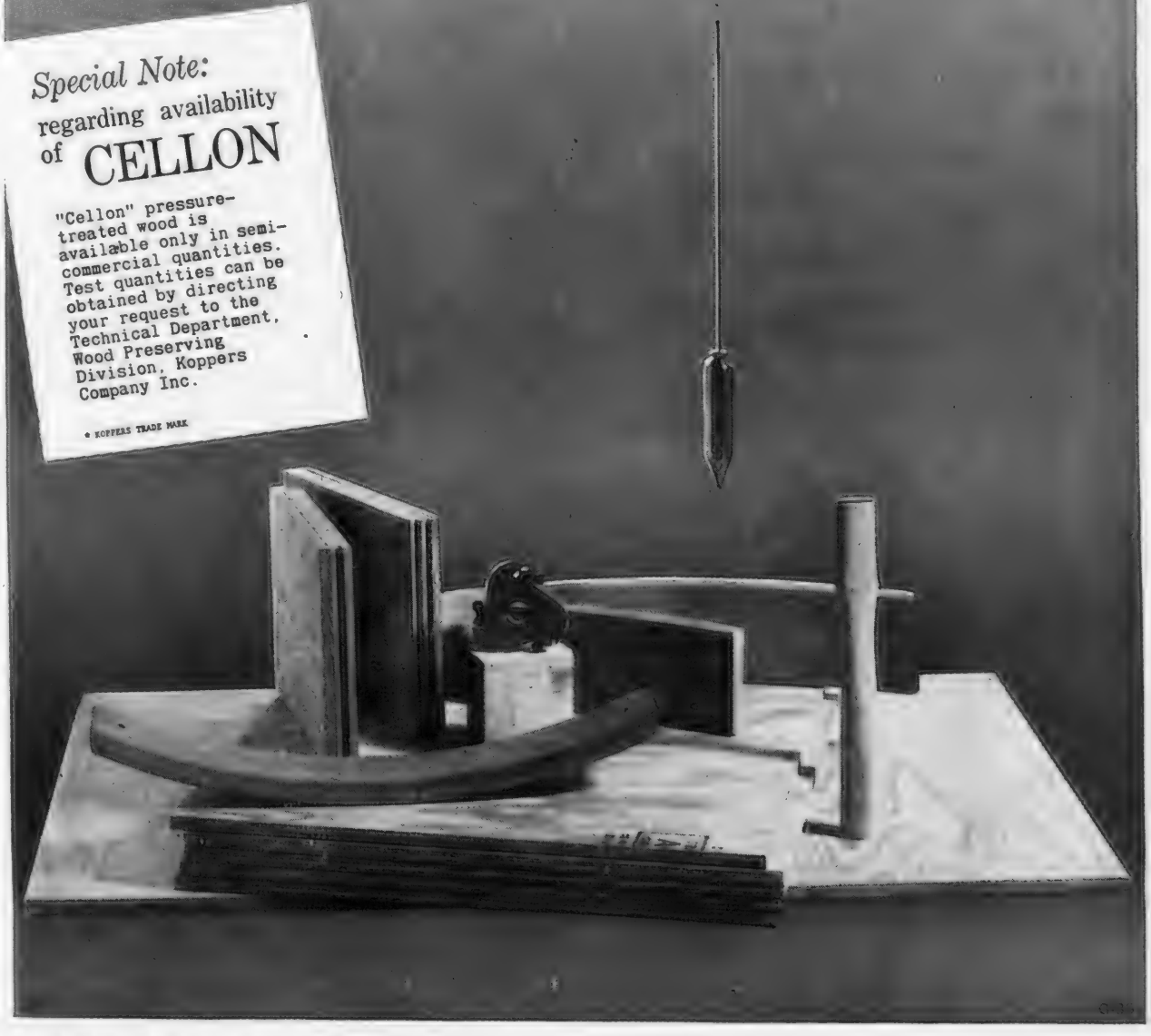
KOPPERS COMPANY, INC.

735 Koppers Building, Pittsburgh 19, Pa.

Special Note:
regarding availability of CELLON

"Cellon" pressure-treated wood is available only in semi-commercial quantities. Test quantities can be obtained by directing your request to the Technical Department, Wood Preserving Division, Koppers Company Inc.

* KOPPERS TRADE MARK



Barrow Lumber Company, Ahoskie, N.C., a Southern Pine Mill Mater "42" Riderless Carriage and Mater Bar Turner

Ahonen Lumber Company, Ironwood, Michigan, softwood and hardwood Mater "Easy Shift" Edger

ACROSS THE NATION SAWMILLS PROFIT FROM MATER "EXPERIENCED AUTOMATION"

MATER
Sawmill Automation
EQUIPMENT

if it's for a sawmill
MATER MAKES IT!

Put Mater Experience to work in your Mill.

Armstrong Lumber Company, Blue River, Oregon, a Douglas fir mill Mater four block High Standard Duty Carriage

leasing available
send for literature

MATER DIVISION OF APPLETON MACHINE CO.

Western Office: P.O. Box 410, Corvallis, Ore., Phone PLaza 3-7335

Eastern Office: P.O. Box 468, Appleton, Wis., Phone REgent 3-7361

TECHNICAL SESSION on chemical conversion was presented by A. J. Stamm, J. R. Saucier, I. S. Goldstein, T. H. Whitehead, F. G. Perry, Jr. and J. B. Doughty.

GLUELINE QUALITY was discussed by Morey Rudhe, C. B. Dosker, Warren Thompson, and R. M. Garratt (rear row) and D. B. Richards, R. H. Ripley, R. F. Blomquist, and Carl McLagen (front row).

PARTICLE & FIBER PROCESSES attracted outstanding turnout in the Terrace Room.

15th Annual Business Meeting

Traditional exchange of gavel between R. H. Berry and incoming president, D. K. Saunders.

. . . "a year of enthusiastic membership activity," W. R. Smith.

. . . "our finances are in reasonably good shape," J. L. Love.

The 15th Annual Business Meeting was called to order by President R. H. Berry at 10:30 a.m., June 19, in The Kentucky Hotel, Louisville, Kentucky, with approximately 200 in attendance. President Berry called on K. E. Huddleston, Executive Secretary, to review the Minutes of the 14th Annual Business Meeting, held June 6, 1960, at Montreal, Canada.

It was moved, seconded, and passed "that the Minutes of the 14th Annual Business Meeting be approved."

Report of Executive Secretary

K. E. Huddleston, Executive Secretary, reviewed the work of the National FPRS office and cited its growth as a service center. He reported that the Society's purchase of offset printing equipment has reduced printing costs by 27 percent. He stated that this and other economies are providing savings and better services for the Sections and the Society's membership.

He extolled the work of the membership in FPRS Sections, Committees, and Divisions—that were the Society able to employ this high quality manpower, it would cost the Society at least from $100,000.00 to $200,000.00 per year. He reported that as the National Office further develops operations as a service center to carry out the objectives of the Society, the staff will more directly serve the best interests of the Society and the membership.

Report of National Membership Committee

Chairman Walton R. Smith used a series of charts in his presentation, which reviewed the status of student, voting, associate, and supporting memberships, *Journal* subscriptions, and the overall membership growth during the past year.

He reported that the June membership of the Society was 4,195. He also reviewed the membership goals which had been established for each Section following the Montreal meeting, and praised the work of the membership chairmen in the 14 Sections. Five Sections had met or surpassed their membership goals in the past year: Mid-South, 156 percent; Pacific Southwest, 150 percent; Southeastern, 120 percent; Carolinas–Chesapeake, 108 percent; Eastern Canadian, 100 percent.

Mr. Smith announced that Harry Russell, membership chairman of the Mid-South Section, which had the greatest membership growth in the past year, would be presented this year's membership award, a solid cherry wood carving of an Irish Setter which had been finished on contract by Harold Luetscher, master craftsman of the U. S. Forest Products Laboratory, at Madison, Wisconsin.

Report of Budget and Finance Committee

Chairman James L. Love reviewed that the Society had instituted a new system of bookkeeping during the past year, the double entry accrual system, with monthly budgets, so that income and expenses are spread evenly over the entire year. With this system, the Executive Board knows month by month the exact financial status of the Society and can trim or expand budget in accord with financial conditions. He reported also that the National Office has been re-organized and the staff is being molded into an efficient and productive unit.

He reviewed that two problems encountered in planning the budget this year were: 1) how much would the increase in dues affect membership; and 2) how much would the recession in the industry affect membership and *Journal* advertising?

He reported that total income for 1961 had been estimated at $114,693, with estimated total expenses being the same amount. Expenses, however, do include an amount for depreciation, and $2,499 as an item for the replacement of working capital which would actually be a savings. For the first 5 months of 1961, income had been estimated at $73,537. Actual income for this 5-month period has been $69,791, a deficit of $3,746. A portion of this deficit will be forthcoming so the actual deficit is only approximately $1,000. He indicated confidence that increased membership and other additional income will take care of this deficit. Expenses to date had been budgeted at $48,508 whereas actual expenses to this date are $48,163. In view of this, Mr. Love stated, the finances of the Society are in reason-

. . . "our Divisions have been established on a working basis," T. S. Veazey.

. . . "we welcome you and hope your stay will be a pleasant one," Carl Trinkle.

. . . "our committee is working to strengthen the review system," H. O. Fleischer.

ably good shape and the Society will have a successful financial year, especially if all its members get behind the efforts of the Membership Committee and help support advertising purchases in the *Journal*.

Report of Division Coordinator

T. S. Veazey, who has served for the past year as Vice President and Division Coordinator, reviewed the work which had taken place at Montreal to reorganize Divisions along process-oriented lines instead of product lines. He pointed out that for the past year efforts have been made to help these Divisions to organize and become established on a working basis. Following the Montreal meeting, the membership had voted affirmatively to give legal status to the new Division organization by a revision of the Constitution to include a section covering the organization of Divisions.

He recognized that some product interested groups wanted product-line Divisions, and this has created a problem to integrate and meet such requests within the process-oriented pattern. He stated that the objective during this meeting is to help the Divisions further organize. He reviewed briefly the plans for the Divisions' business meetings to be held on Tuesday afternoon.

Mr. Veazey then reviewed the objectives of each Division and indicated further growth of Division activities by Divisions taking greater responsibility in originating papers for the Annual Meeting and for use in the *Journal*. Looking ahead, he reviewed briefly that a timetable had been developed so that Divisions could move ahead more actively in planning for the technical programs for forthcoming Annual Meetings.

Report of Annual Meeting Committee

Chairman Carl Trinkle reported that as of Monday morning, June 19, there were more than 300 full-time registrants in attendance, but that it was too early to indicate the total final attendance because one-day registrants were continuing to register. He indicated that this year's Annual Meeting would be in the black financially.

Report of Ways and Means Committee

Charles Kreider, Chairman of this activity, reported that the Committee had just completed a survey of a number of Supporting Members pursuant to recommending to the Executive Board that the current structure of $100 dues for Supporting Members be changed to where companies would pay for Supporting Memberships on a sliding scale based on production or sales. He said the survey disclosed that a number of companies are willing to pay considerably more for Supporting Membership in the Society if the new dues structure is applied across the board for all Supporting Members. During this survey, a number of companies indicated that they would like to contribute additional amounts to the Society because of the worthwhile work being done and have done so. Mr. Kreider said that his report would be presented to the Executive Board for action during this Annual Meeting.

. . . "many members are willing to give additional support to FPRS," C. M. Kreider.

Report of Publications Committee

Chairman H. O. Fleischer reviewed the progress that has been made in the *Journal*. He pointed out that the *Journal* is now coming out on the first of the month, that the backlog of papers has been reduced, and that new papers can be scheduled for early publication. The current work of the Committee is toward strengthening the review processes, defining the types of papers recommended for the *Journal* so that there can be good editorial balance.

In reviewing the *Journal* for the year 1960, he stated that for this period the *Journal* had published 800 pages of editorial material compared to 735 pages in 1959. This included 142 technical articles compared with 133 in 1959. As of the June issue of 1961, the *Journal* has published the first 6 months this year a total of 385 pages, including 64 articles for a total of 282 pages, and 103 pages of news digests, service material, and advertising.

Report of FPRS Editor

John McDonald, Editor of the *Journal*, stated that Dr. Fleischer had reviewed the progress in editing the *Journal* and confirmed the point that the *Journal* will maintain its schedule. He further emphasized that the backlog of papers had been reduced and that new papers will receive early pub-

. . . "we can now promise fairly early publication," J. K. McDonald.

. . . "the Employment Committee is being reorganized," W. C. Hopkins.

. . . "the recent changes in the constitution have strengthened FPRS," A. F. Muschler.

lication. He asked for complete cooperation from Division chairmen in obtaining their reports because of the critical scheduling of the *Journal* which requires that copy be sent to the printer earlier than heretofore. Reviewing that the "Yearbook" issue of the *Journal* is now September where prior to now it has been in October, this advances considerably the date that Division reports are needed. Mr. McDonald mentioned briefly the "Cross Section" of membership views in the *Journal* urging that members make use of this page to discuss the pros and cons of questions.

Report of Employment Committee

Chairman William Hopkins reported that the Committee had followed through with the summer employment program for students. However, the results were not satisfactory this year because of the recession in the industry and the reports from companies that any job availabilities would be given to those who had been released because of the recession. He said that the Employment Committee is being reorganized, and a study is being made of the value of the summer employment program. Colleges have their own employment programs and are much closer to the scene; therefore, it is very possible that the summer employment program for students should be dropped, with further strengthening the current employment program to help manufacturers locate personnel and to help those seeking jobs develop contacts with those seeking employees. Mr. Hopkins said that the Employment Committee would hold open-house to review job openings with those seeking employment and to take listings from employers seeking personnel.

Report of Constitution and By-Laws Committee

Chairman A. F. Muschler reviewed that there had been two constitutional amendments passed by members during the past year. One formally established Divisions. The other increased the dues for all voting and associate members in the Society to $20.00 per year and established members' dues on a yearly basis from the date they join. He pointed out also that there have been two amendments to the By-Laws. One adjusted the date when a member becomes delinquent for non-payment of dues so that he is delinquent if he has not paid his dues within 6 months following the anniversary date of his membership. The other By-Law change legalized the organization of local student chapters.

Report of Tellers' Committee

Chairman W. J. Eason reported that in accordance with the Constitution, voting members of the Society had been mailed ballots covering the election of President-elect, Vice President, two Regional Board Members, and four individuals to serve with the two last Presidents not serving on the Board to form the Nominating Committee for 1962. He reported that the Tellers' Committee had counted ballots and declared the following officers as elected for the forthcoming year, 1961–1962: President-elect, T. S. Veazey; Vice President, F. E. Dickinson; North Central Board Member, A. F. Muschler; Southwest Board Member, MacGregor Graham. Chairman Eason then announced the following individuals as elected to the 1962 National Nominating Committee: Richard E. Blomquist, R. W. Wellwood, Ralph H. Bescher, and Herbert B. McKean.

. . . "your ballots contained many interesting items," W. J. Eason.

Resolutions

President Berry asked those in attendance to stand in a moment of silence in remembrance of the following members who had passed away during the past year:

Joseph L. Noyes, Marshall Lumber Co., Box 559, Marion, North Carolina.

Edmund F. Oeffinger, United States Plywood Corp., Orangeburgh, South Carolina.

A. R. Tegge, Jr., Quartermaster Food & Cont. Inst., 1819 W. Pershing Road, Chicago 9, Illinois.

C. G. Murphy, E. I. Du Pont De Nemours & Co., 35th and Grays Ferry Avenue, Philadelphia 46, Pa.

J. A. Denton, 2834 N. E. 39th Street, Portland 13, Oregon.

Oscar H. Nuss, DeWalt, Inc., Fountain Avenue, Lancaster, Pa.

Howard M. Brown, Box 2097, Fullerton, California.

MacGregor Graham is welcomed to the Board by President D. K. Saunders.

W. Kay Conard, The Collier Co., Everglades, Collier County, Florida.

James H. Skalley, 2205 Eastmont Way, Seattle 99, Washington.

Dr. G. G. Klem, The Norwegian Forest Research Institute, Vollebekk, Norway.

Giovanni Colucci, President, Southern Box & Lumber Company, Box 627, Wilmington, North Carolina.

L. J. Carr, L. J. Carr Company, P. O. Box 282, Sacramento, California.

Peter A. Solem, President, Solem Machine Co., Merritt–Solem Division, Rockford, Illinois.

Philip H. Creden, Edward Hines Lumber Co., 200 S. Michigan Avenue, Chicago 4, Illinois.

L. T. Sandborn, Assistant Director of Research, The Crossett Company, Crossett, Arkansas.

Philippe R. LaSage, 4427 Melrose Avenue, Montreal 28, Quebec, Canada.

The motion was made, seconded, and passed that the following resolution be enacted:

"That the Louisville Annual Meeting Committee be commended for its outstanding performance and that there be an expression of appreciation by the membership to each member of this Committee."

The motion was made, seconded, and passed that the following resolution be enacted:

"That the membership of the Society express its appreciation to the management of the Kentucky Hotel for the outstanding cooperation of its staff in arranging this Annual Meeting of the Society."

Report of Preprint Survey

President Berry reviewed that at the Montreal business meeting of the Society, motion had been passed as follows: "That within the next few months, the FPRS office conduct a mail survey of members to ascertain their opinion on the preprint question."

President Berry indicated that such a survey had been conducted, and that the returns indicated 504 for preprints, 500 against preprints, with 92 votes not being included with the above in which members indicated for and against with varying comments, which made it difficult to actually ascertain the intent of the vote. He said that the matter is being reviewed by the Executive Board, and that a decision would be made at a later date.

New Business

As to new business, the following action was taken. The motion was made, seconded, and passed:

"That all of the foregoing reports be accepted with commendation to all individuals, Committee chairmen, and Committee members for their efficient and hard work."

The motion was made, seconded, and passed:

"That the Forest Products Research Society endorse National Forest Products Week to be held the week beginning October 15, and urge all members to take advantage of this opportunity to help bring about among people in general better appreciation of wood."

Question was raised by a member as to how many copies of the *Journal* are available to a Supporting Member for his membership, that some Supporting Members feel that extra copies of the *Journal* should be available. He pointed out that if extra copies are not available, one Supporting Membership indicated the membership would be dropped and four or five voting memberships taken out instead so as to provide these additional copies of the *Journal*.

President Berry pointed out that under the Constitution, Supporting Memberships exist for a company to give extra support of the Society. He felt that if Supporting Memberships were given extra copies of the *Journal*, each subscription costing an actual outlay of approximately $15.00 per year, this would defeat the intent of Supporting Memberships. Under such a pattern, Supporting Memberships would no longer be a source of extra income for the Society.

President Berry announced that the 16th Annual Meeting of the Society will be held in Spokane, Washington, June 24–28, 1962.

Adjournment

Motion was made, seconded, and carried:

"That the 15th Annual Business Meeting be adjourned."

The meeting was adjourned at 12:15 p.m.

Committee Named for FPRS 16th Annual Meeting

The following men have been named to man the various committee functions of the Society's 16th Annual Meeting, which is scheduled for Spokane, Wash., June 24–28, 1962.

General chairman: R. E. Jones, Lumber By-Products Co., Spokane, Wash.

Executive board liaison and technical program chairman: T. S. Veazey, Anaconda Co., Bonner, Mont.

Planning and arrangements for technical program: G. G. Marra, Washington State Institute of Technology, Pullman, Wash., chairman; and C. M. Kreider, Brooks–Scanlon, Inc., Bend, Oregon.

Budget and finance: R. L. McNett, Biles–Coleman Lumber Co., Omak, Wash., chairman; H. R. Dix, Anaconda Co., Bonner, Mont.; and, G. F. Jewett, Potlatch Forests, Inc., Lewiston, Idaho.

Publicity: V. A. Warren, Virgal A. Warren Advertising Agency, Spokane; and R. W. Olin, Potlatch Forests, Inc., Lewiston, Idaho.

Paul Bunyan party: C. J. Warren, Intermountain Lumber Co., Missoula, Mont.; and A. W. Olson, Missoula White Pine Sash Co., Missoula, Mont.

Information: Steele Barnett, Boise-Payette Lumber Co., Boise, Idaho; and Karl Bollerslev, Boise-Cascade Corp., Boise, Idaho.

Transportation: D. W. Walters, Inland Empire Industrial Research, Spokane, Wash.

Exhibits: R. J. Hoyle, Jr., Potlatch Forests, Inc., Lewiston, Idaho, chairman; R. A. Crowe, Missoula White Pine Sash Co., Missoula, Mont.

Plant tours: H. B. McKean, Potlatch Forests, Inc., Lewiston, Idaho; and R. D. Brown, Long Lake Lumber Co., Spokane, Wash.

Hotel arrangements: Hamilton Owens, Spokane Chamber of Commerce; W. E. Irwin, Western Pine Manufacturing Co., Spokane, Wash.; J. L. Alport, Anaconda Co., Missoula, Mont.; and William Newman, assistant manager, Davenport Hotel, Spokane, Wash.

Visual Aids: J. P. Howe, University of Idaho, Moscow, Idaho; J. P. Krier, Montana State University, Missoula, Mont., co-chairmen; and H. E. White, St. Maries Lumber Co., St. Maries, Idaho.

Mechanized gluing operation; (1) framing members are mechanically fed through glue spreader, (2) framing members are then assembled on hardboard, (3) after assembly, panel lay-ups are placed on conveyor, (4) and (5) lay-ups are positioned in gluing press.

How National Casein helped Cornwell Co. Inc. save $75 a day...and more!

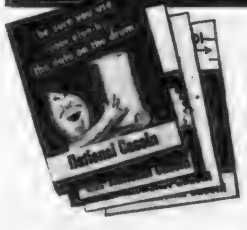
New glue additive eliminates the need for presanding tempered hardboard before gluing

In the manufacture of TV and Hi-Fi cabinets, Cornwell Company Inc. of Paoli, Indiana must glue tempered hardboard to wood frames. Because the glue can not get a good "bite" through the glazed surface, the hardboard had to be presanded before gluing, an operation that was both costly and time-consuming. On humid days, additional press time had to be allowed to secure adequate bond.

To improve this process, Bob Allen, the National Casein glue man who calls on Cornwell, huddled with the company's production team. As result, National Casein developed LG-40, an additive for mixing with their No. 30 Casein glue to provide an excellent bond without presanding the hardboard. Moreover, only a 45-60 minute press time was now required, even on humid days, a development that facilitated higher production speeds.

The savings to the Cornwell Co. are many. By eliminating presanding, the firm saves $75 and six man-hours per day in sanding costs. In addition, they save approximately $200 a month in glue costs.

By eliminating presanding, plus mechanizing their gluing operation (see below) the Cornwell Co. has increased production 11% to 2400 hardboard panels a day . . . yet has reduced labor costs 50%.



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Set of four colorful 10" x 13" wall posters to help woodworkers achieve better gluing results.

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National Casein Company, 610 W. 80th Street, Chicago 20, Ill.
and Tyler, Texas

National Casein of New Jersey, Broad & Fulton Streets, Riverton, N. J.

Highlights of Executive Board Meetings

In two hard-working meetings at Louisville, the Executive Board continued its dedicated work to further the best interests of the Forest Products Research Society. Much of the first meeting, which was called to order Sunday noon by President—now Past President R. H. Berry, has been outlined in the minutes of the annual business meeting, which are published elsewhere in this issue. Here are a few of the highlights of the second meeting, which was called to order by President D. K. Saunders Thursday, June 22:

FPRS EXECUTIVE BOARD 1961–62: Back row, left to right: Regional Board Members, James L. Love, South-Central; Eric A. Anderson, Northeast; Arthur F. Muschler, North-Central; Walton R. Smith, Southeast; and MacGregor Graham, Southwest; and Executive Secretary, Kenneth E. Huddleston. Front raw, left to right: Executive Board Members, E. S. Harrar, Advisory Committee Chairman; T. S. Veazey, President-elect; Raymond H. Berry, Past President; Donald K. Saunders, President; Fred E. Dickinson, Vice-President; and Robert J. Seidl, Northwest.

Past President's Advisory Committee

At previous meetings of the Executive Board and the Executive Committee, R. H. Berry recommended that the invaluable experience of past presidents of the Society be utilized by the creation of a permanent Policy Committee whose members would be past presidents.

In Louisville, the Board received and approved a report presented by E. S. Harrar, chairman of the past-presidents', group which requested that they be designated an "Advisory Committee to the Executive Board."

Dr. Harrar's report requested that the committee not be governed by "ground rules", but rather that it should be free to concern itself with any matter and to take whatever course of action seemed most appropriate in study and counseling, and in making recommendations to the Board.

In this, their first report to the Board, the Advisory Committee recommended that the Executive Board "critically review the basic precepts and objectives outlined with the founding of the Society, and employ their principles when and wherever necessary to provide maximum harmony within the Society."

In other recommendations, the committee asked that the Board emphasize to national nominating committees the necessity for maintaining interests-balance among the Society's national officers; that every reasonable effort shauld be made to beam a part of national meeting programs at local interest groups in the convention area; and that the Board re-examine all fee schedules of future national meetings.

Review of National Meeting Papers

The Executive Board, at the request of numerous division chairmen and members, had previously considered the advisability of review of annual meeting papers. After some discussion, a motion was passed to the effect that:

"The President Elect, as 1962 National Technical Program Chairman, be authorized to advise the Division Chairmen that they should provide for review of all annual meeting papers within the respective division; that the Publications Committee should be asked for suggestions as to capable reviewers; and that the appointment of annual meeting paper reviewers is the responsibility of Division Chairmen."

Supporting Membership Dues

C. M. Kreider, Chairman of the Ways and Means Committee, presented several proposals for changes in the dues structure of supporting memberships. His recommendations were based on a survey of a cross section of these members which indicated that supporting members had a definite preference for a sliding-scale based on annual sales or production.

Chairman Kreider also reported that a survey had evoked considerable interest from numerous industries and organizations outside of the forest products industry, yet indirectly related to the industry. Many of these concerns indicated a willingness to become sustaining or supporting members of FPRS.

Chairman Kreider's report was accepted with commendation and the Board indicated further action would be taken at its next meeting.

Section Boundary Change

For some time, an area in British Columbia has been included in both the Pacific Northwest and the Inland Empire Sections. To relieve this difficulty, officers of the two Sections recommended that the Inland Empire retain the area now included within its by-laws in Canada, and that the Pacific Northwest alter its by-laws to relinquish that area of British Columbia east of the Cascade Mountains.

Other Business

In other actions, the Board designated the president, past-president, president elect, vice president, and the chairman of the budget and finance committee as the Executive Committee empowered to act on the Board's behalf.

Both the Section and Division Officer's Advisory Committee reports were accepted and approved, and the various recommendations and suggestions will be acted on in the future.

Next Board Meeting

The next meeting of the full Executive Board is tentatively scheduled for October 23–24, at the National Office in Madison. The Executive Committee will probably hold a meeting prior to then.

TWO YEAR Performance REPORT The Taylor MIX-MIZER

Sanford Furniture Company, Sanford, North Carolina reports after two years' operation of the new Taylor Mix-Mizer for automatically proportioning and mixing urea resin glue:

"We are most happy with the job this machine is doing. When our Panel-Flo was running at full capacity we kept one man busy mixing glue. Now with the Mix-Mizer that man is no longer necessary.

We have experienced considerable saving in the amount of glue we use, and also find we are getting more accurately measured and more thoroughly mixed glue than when we mixed by the old method."

At left is a view of the Taylor Mix-Mizer mounted on a *Taylor Panel-Flo* at Sanford Furniture Company.

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Paul Bunyan Cruise a Memorable Evening

A total of 470 FPRS members and guests enjoyed a unique 4-hour cruise down the Ohio River on the Steamer Avalon, Monday, June 19, at the 15th Annual Meeting in Louisville, Ky. Food and refreshments were served with true "southern hospitality," as the registrants stacked plates high with finger-licking fried chicken, baked ham, baked beans, and all the trimmings. Refreshments were equally bountiful.

The Avalon's famed steam calliope recalled the bygone days of the river, and a Dixie Land Band provided excellent background music. Nature cooperated with superb weather, including a gorgeous sunset and a new moon.

The cruise, which was pronounced a great success by everyone, presented an excellent opportunity for all on board to visit and discuss problems of mutual interest.

This year's Paul Bunyan party was sponsored by 62 wood products manufacturers and industry suppliers. FPRS is indebted to the gracious hospitality of the following firms and organizations:

Paul Bunyan Sponsors

American Cyanamid Co., New York, N. Y.
American Manufacturing Co., Tacoma, Wash.
American Marietta Co., Seattle, Wash.
Arnold Dryer Co., Milwaukee, Wis.
Bahnson Co., Winston–Salem, N. C.
Behr–Manning Co., Troy, N. Y.
Binks Manufacturing Co., Chicago, Ill.
Birds Eye Veneer Co., Escanaba, Mich.
Black Brothers Co., Inc., Mendota, Ill.
Borden Chemical Co., New York, N. Y.
Carborundum Co., Niagara Falls, N. Y.
Catalin Corp. of America, New York, N. Y.
Chain Belt Co., Milwaukee, Wis.
Chapman Chemical Co., Memphis, Tenn.
Cleworth Publishing Co., Cos Cob, Conn.
The Coe Manufacturing Co., Painesville, Ohio
Peter Cooper Corporations, Gowanda, N. Y.
The Crossett Co., Crossett, Ark.
Devoe & Raynolds Co., Inc., Louisville, Ky.
Diamond National Corp., Red Bluff, Calif.
Dow Chemical Co., Midland, Mich.
Franklin Glue Co., Columbus, Ohio
Gamble Brothers, Inc., Louisville, Ky.
Edward Hines Lumber Co., Chicago, Ill.
Hitchcock Publishing Co., Wheaton, Ill.
Hoosier Panel Co., Inc., New Albany, Ind.
Koppers Co., Inc., Pittsburgh, Pa.
The Lilly Co., High Point, N. C.
Lilly Varnish Co., Indianapolis, Ind.
Masonite Corp., Chicago, Ill.
Mereen–Johnson Machine Co., Minneapolis, Minn.
Minnesota Mining & Manufacturing, St. Paul, Minn.
Monsanto Chemical Co., Seattle, Wash.
Moore Dry Kiln Co., Jacksonville, Fla.
National Casein Co., Chicago, Ill.
National Lumber Mfr's Assn., Washington, D. C.
National Polychemicals, Inc., Wilmington, Mass.
National Starch Products, New York, N. Y.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Pacific Lumber Co., San Francisco, Calif.
Perkins Glue Co., Lansdale, Pa.
The H. K. Porter Co., Philadelphia, Pa.
Porter Paint Co., Louisville, Ky.
Potlatch Forests, Inc., Lewiston, Idaho
Preston Woodworking Machinery Co., Ltd., Preston, Ontario
Protection Products Manufacturing Co., Kalamazoo, Mich.
Rader Pneumatics, Inc., Portland, Ore.
Reichhold Chemicals, Inc., White Plains, N. Y.
Reliance Varnish Co., Louisville, Ky.
The Schaefer Varnish Co., Louisville, Ky.
Scott Lumber Co., Inc., Burney, Calif.
Simonds Saw & Steel Co., Fitchburg, Mass.
Simpson Timber Co., Seattle, Wash.
Ralph L. Smith Lumber Co., Anderson, Calif.
Standard Dry Kiln Co., Indianapolis, Ind.
Chester B. Stem, Inc., New Albany, Ind.
Synvar Corp., Wilmington, Del.
U. S. Plywood Corp., New York, N. Y.
Washington Iron Works, Seattle, Wash.
West Coast Lumbermen's Assn., Portland, Ore.
Weyerhaeuser Timber Co., Tacoma, Wash.
Wood–Mosaic Corp., Louisville, Ky.

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FPRS Section Officers Meeting

The meeting was called to order at 8 p.m., June 20, 1961, by Robert J. Hoyle, Past Chairman of the Inland Empire Section. An interchange of information of the frequency of section meetings and types of programs was discussed. The need for division liaison officers in each section and the responsibility for the appointments being assumed by the divisions was expressed. Clarification by the Executive Board was requested on this matter.

The use of National Office services for mailing and printing of meeting notices was encouraged. Sections were urged to forward papers to be presented at section meetings to the *Journal* editor. There was some question as to the screening of this material for publication.

Resolutions

Several resolutions were passed. They are as follows:

1) The Executive Secretary should notify all officers of each section of the time, place, and purpose of the annual Section Officers' Advisory Committee meeting. The purpose of this is to better prepare the section representatives to use this meeting effectively.

2) The Section Officers' Advisory Committee commended the Executive Secretary, Kenneth Huddleston, and his staff for the services provided by the National Office to the sections during the past year. Commendation was also extended to John McDonald for his performance as Editor and for his accomplishment in placing publication of the *Journal* on a regular schedule.

3) The Honorarium Lecture was to be continued when an outstanding recipient exists, but a monetary award should be replaced with a placque or scroll. If a monetary award was given, the sum should be obtained from Society general funds rather than solicitation of the sections. The fund, if awarded, should be derived by a method which taxes each section in an equitable fashion.

4) The practice of mailing copies of all section meeting programs and newsletters to all officers of all sections should be continued. This may best be accomplished by having the National Office append a list of all officers of all sections to mailings handled by the National Office for the sections.

Attendance

Attendance at the Section Officers Meeting consisted of: E. Clarke, Chairman, D. Burnet, Vice Chairman, Pacific Northwest Section; R. F. West, Chairman, R. Gale, Secretary, Northeastern Section; J. Hamilton, Secretary, Southeastern Section; M. A. Taras, Chairman, Carolinas–Chesapeake Section; W. A. Gullicksen, Chairman, K. Kimball, Secretary, Mid-West Section; J. Neetzel, Treasurer, Upper Mississippi Valley Section; N. C. Franz, Chairman, Great Lakes Section; G. Glennie, Trustee, Eastern Canadian Section; E. Ellwood, Vice Chairman, Northern California Section; C. Smith, Trustee, Mid-South; and R. J. Hoyle, Past Chairman, Inland Empire Section.

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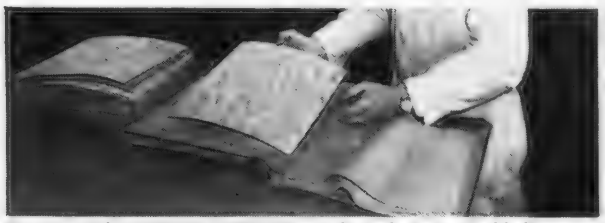

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Division Officers Meeting

T. S. Veazey, FPRS President-elect, opened the meeting and greeted the division officers present. Dr. Blomquist accepted the chair for the meeting since he had done so last year. Wayne Lewis was appointed to act as secretary pro tem.

Liaison Members Requested

The question had been raised at several of the division meetings for a classification of the procedure for the official liaison members from the sections. Paul Heller pointed out that he had tried to get section chairmen to nominate men from their section and 50 percent of the appointments were men who did not belong to the division appointed. Fred Perry pointed out that the sections made the appointments, but the Division Officers Guide implied the appointment came from the division. Dr. Robert Youngs indicated that a section chairman or section program chairman could and should correspond directly with the division chairman when he needed help on a program. Dr. Blomquist indicated that ideally the appointment of section representatives on divisions should tie together the activities of sections and divisions. It is requested that the executive board clarify the appointment procedure.

Subdivisions

Subdivisions within divisions were discussed. Paul Heller indicated that his division on Timber Production had two subdivisions: one on saw milling, another on machining. Bob Youngs reported that his division was feeling its way and as yet had no break down. Division 5 "Particle & Fiber Processes" so far had not developed any subdivisions within its group. It was the consensus that further experience would indicate the preferences for division makeup in that line.

Timetabling Papers

Arthur Mottet announced that Division 5 had voted to recommend that in future conventions an actual timetable for specific papers be adopted as an aid to permitting people to split their time into different sessions so that they could hear more papers of their specific interests. It was moved by J. J. Allegretti, seconded by Fred Perry, and carried that it be recommended to the Board that the sessions be timetabled by papers and included in the program so that attendees can decide when to attend specific sessions.

Wood Award Papers

Dr. Youngs discussed the scheduling of the Wood Award papers. The possibility of including it as a part of the general session appeared unsatisfactory. This year it was in his division, and he moved that the Wood Award paper be regularly scheduled at the initial session of Division No. 1. It was seconded by James Snodgrass, and after considerable discussion which indicated that the paper was most likely to be of a fundamental nature, the motion was carried.

Name Change

Because of a vote in his division James Snodgrass moved that the executive board change the name of the division from "Engineering" to "Wood Engineering." The motion was seconded by Lewis and carried.

Steering Committees and Speakers

The matter of steering committees was discussed. Apparently only Division 5 has such a control group. Other committees had an extra officer in some instances who was called a second vice chairman (1963 potential program chairman) who assisted in serving on a control group with other officers. The Steering Committee of Division 5 was a carry-over from an old appointment made by the Board. Mr. Mottet requested some clarification by the Board so they would know whether it should be continued.

The matter of speakers at sessions where they had no formal papers was discussed. It was emphasized that wherever possible formal papers were desirable since their publication in the *Journal* was very important to the Society. The example was given by Fred Dickinson of an eminent architect who made a very stimulating presentation at the San Francisco National Meeting. He made a major contribution to the meeting but would not have been there at all if it had been necessary that he prepare a formal paper. It was agreed that the program chairman should exercise their best judgment in this matter for future meetings.

Future Plans

Wayne Lewis asked that program chairman be sent sets of hotel reservation forms and other meeting information to transmit to prospective speakers who were not members of the Society. After discussion it was agreed that the proper procedure would be to have program chairman send a list of prospective speakers to the National Office who would be responsible for getting such information as was necessary to them pertinent to the meeting itself.

The matter of registration fees for people who present papers was discussed. Mr. Allegretti pointed out that within the existing framework of the Society it would be possible for a division to pay the necessary registration fee (exclusive of meals, etc.) for nonmember speakers. It was agreed to request the executive board to set a specific procedure pertaining to nonmember speakers at Society national meetings.

Mr. Allegretti introduced and discussion followed on the desirability of a directory of members with divisional interests indicated. If this directory were on a geographical basis, section orientation would be automatic. It was moved, seconded, and approved that the Executive Board be asked to consider publication of a directory this next year.

Attendance

Those in attendance were: T. S. Veazey, FPRS President-elect; W. Lewis, Vice Chairman, Particle and Fiber Processes; J. D. Snodgrass, representing J. Hoyle, Jr., Engineering; F. E. Dickinson, FPRS Vice President; G. Vasiliou, Vice Chairman, Production Management; William B. Lloyd, Temporary Chairman, Marketing; W. H. Reid, Marketing; R. L. Youngs, Chairman, Anatomy and Fundamental Properties; C. B. Hemming, Vice Chairman, Glues and Gluing; F. G. Perry, Past Chairman, Chemical Conversion; W. J. O'Neil, Secretary, Timber Production; J. A. Doyle, Chairman, Timber Production; F. W. Herrick, Vice Chairman, Chemical Conversion; P. Heller, Chairman, Mechanical Conversion; C. W. McMillin, Secretary, Mechanical Conversion; R. S. Millett, Past Chairman, Drying; J. F. Saeman, Chairman, Chemical Conversion; A. L. Mottet, Chairman, Particle and Fiber Processes; R. F. Blomquist, Chairman, Glues and Gluing; J. J. Allegretti, Chairman, Production Management; and O. G. Sherman, Marketing .

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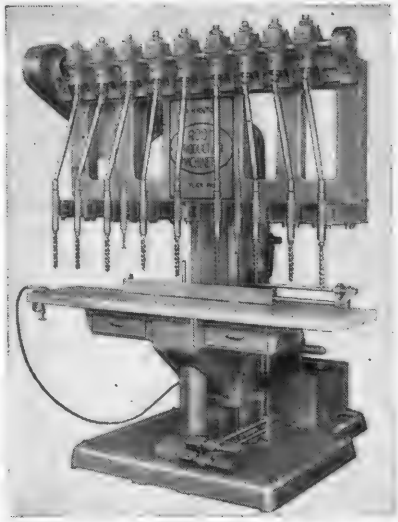

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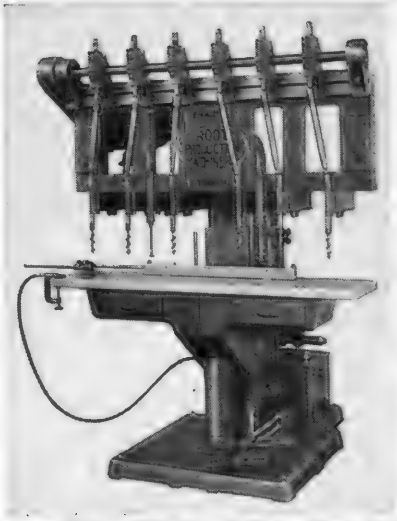

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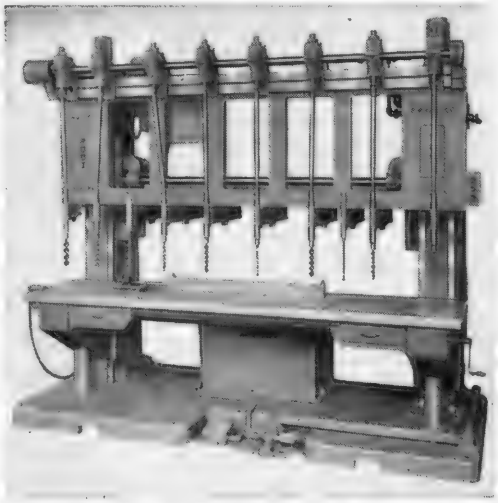

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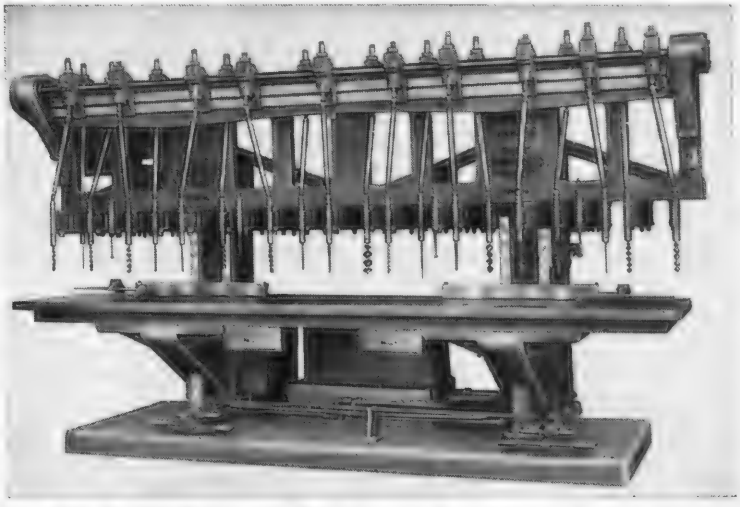

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Glues and Gluing Discuss Advantages of Panels

The Business Session of Division 6, Glues and Gluing, was opened at 4:30 p.m., June 20, 1961, at Louisville, Kentucky, by the Chairman, R. F. Blomquist. Approximately 35 members were in attendance.

Nominating Committee

The first business was a report by the Nominating Committee, chairmanned by W. T. Nearn. The Nominating Committee members were R. H. Ripley and John L. Butler. Dr. Nearn made a motion that the following slate of officers be accepted for Division 6 of the Forest Products Research Society for the ensuing year: Chairman, R. F. Blomquist; Vice Chairman, Charles B. Hemming; and Secretary, Curtis Booth. The motion was seconded by John Sullivan. Larry Clark made the motion that the Secretary cast a unanimous ballot for the officers as presented; it was seconded by Frank Kaufert, and carried.

Activities

The activities of the past year were reported on by Chairman Blomquist and repeated here was then a review of the present organization of the Division since its creation at the 1960 Annual Meeting. Six subdivisions have been formed and the chairman selected for each subdivision. Each chairman has in this committee at least one representatives of each of the Sections of the Forest Products Research Society. This group will act as an informal steering committee for the Spokane meeting.

Chairman Blomquist reported on the results of questionnaires sent to members during the year—a good response, 120 questionnaires returned or received, with many helpful comments. Chairman Blomquist briefly expounded on several of the comments.

A motion was made by Frank Kaufert, seconded by John Sullivan that two half-day typical sessions be presented at the Spokane meeting and the motion carried. It was recommended that these sessions be on the same day or two adjacent days to benefit those who cannot stay for the whole meeting. J. F. Hamilton recommended that representatives in the Empire Section develop a theme for the technical sessions that would be appropriate to that area. R. S. Burnett suggested papers on protein glues because of the large usage on the West Coast. Suggestions for authors and papers were to be submitted to C. B. Hemming as soon as possible. C. B. Hemming asked for comments on papers, persons for panels for technical sessions. The advantages of panels were that 1) they get a better informal discussion; and 2) they get men too busy to prepare papers. The disadvantage was those not attending the meetings miss the information expounded by panel presentation—in this vein, it was suggested that the gist of the questions and answers be recorded for print.

Don Burnet brought out the disadvantage of the plywood falling under three Divisions, that is, Division 3, Conversion; Division 8, Drying; and Division 6, Glues and Gluing. Discussion by Mr. Veazey and others followed. It was left that the West Coast group would decide on the proper place for the papers at the Spokane meeting and that a big play will be given by Division 6 for plywood at the next meeting.

A bibliography prepared by Ben S. Byrant of 1960 publications on glues and gluing was passed out to members present.

Bark Mulch Standardization

The meeting was called to order by acting chairman, J. J. Allegretti. It was decided that the problem on Bark Mulch Standardization would fall under the sponsorship of the Production Management Division of FPRS at the present time.

Attendance

The following companies were represented at this meeting as well as the Forest Products Laboratories at Madison, the Central States Forest Experimental Station at Columbus, Ohio, the School of Forestry of the University of Minnesota, the Vermont Bureau of Industrial Research, and the California Redwood Association. The companies are as follows: Miramul, Inc., Diboll, Texas; Chesapeake Corporation of Virginia; the Crossett Company, Crossett, Arkansas; the M & O Paper Company, International Falls, Minnesota; Mater Engineering Company, Corvallis, Oregon; the International Paper Co., Longview, Washington; Brooks–Scanlon Company, Bend, Oregon; Weyerhaeuser Company, Tacoma, Washington; Scott Lumber Company, Burney, California; Allan Products Company, Adel, New Jersey.

Activities

The group was brought up to date on the activities of some of the producers by a number of people, including the Barrel Company. The Miramul Company spoke a little about their activities, Scott Company talked about their activities, and the overall interest in this meeting was brought about by many of the large company interests in forest products made from surplus bark. Some of the companies involved had as much as 200 tons of mug a day available and are much interested in what can be done with the bark. It was therefore agreed, and a motion was passed and seconded, that a technical sub-committee be appointed to develop specifications for bog soil additives and mulches. A second motion was passed that standards for sawdust mulching be developed as soon as bog standards have been established. The sub-committee comprised of Mr. Barrel of the Barrel's Company, Mr. James L. Love of Miramul, Inc., Diboll, Texas, Mr. Stanley Gregory, Weyerhaeuser Company, and Mr. J. J. Allegretti met after the meeting was over and decided on certain action to be taken as soon as possible.

Since the members of FPRS that met at this meeting did not represent all of the bark producers, the sub-committee decided to alert all bark producers in the country to the immediate action that was taken at this meeting. They will point out that FPRS is going to spearhead the action toward standardization of bark specifications for soil additives and mulches and seek cooperation from all producers in this area with the possibility of setting up a bark producers council or some similar organization. Those who are interested may write to J. J. Allegretti, Scott Lumber Co. for further information. In the meantime, as soon as it is practical, other bark producers will be advised of action taken at this meeting.

Anatomy and Fundamental Properties Retains Officers

In its first year of operation, the Division of Anatomy and Fundamental Properties has shown that it can and does serve a real need in FPRS. By providing a forum for presentation of good basic research papers and a means of engineering research and preparation of such papers, the division is adding considerably to the depth of coverage of the field of forest products provided by FPRS.

Annual Review

A review of recent developments in research on the basic physical and mechanical properties of wood was prepared during the year and published in the *Journal*. Indications are that this review is serving a useful purpose for both researchers and producers. Plans are underway to prepare a similar review during the coming year, probably in the field of wood anatomy.

Research Papers

Considerable effort during the year was put into securing good research

papers for presentation at the two technical sessions of the division in Louisville. This effort, spearheaded by Vice Chairman Alan Marra, was amply rewarded in Louisville in the form of two outstanding technical sessions that made a significant contribution to the overall value of the National Meeting. Further, the success of their efforts was real encouragement and challenge to do as well next year at the National Meeting in Spokane.

Wood Award

Each of the two sessions included three regularly scheduled presentations with generally adequate time for discussion. In addition, we were privileged to have the 1961 Wood Award paper presented at the first session. Since inclusion of the Wood Award paper did force some shortening of the regularly scheduled papers, however, it is anticipated that this paper will be scheduled for one of the division's technical sessions next year with a definite time allocation.

Officers

Officers of the division for 1960–61 will continue to hold their posts for 1961–62. They are: Chairman, Robert Young, U. S. Forest Products Laboratory, Madison, Wisconsin; Vice Chairman, Alan Marra, University of Michigan, Ann Arbor, Michigan; and Secretary, Michael Taras, Southeastern Forest Experiment Station, U. S. Forest Service, Asheville, North Carolina.

Engineering Division Changes Title

The division business meeting of the Engineering Division was held June 20, 1961. The temporary Chairman was R. J. Hoyle, Potlatch Forests, Inc. The temporary Secretary was James B. Snodgrass of Oregon Forest Research Center, Corvallis, Oregon. The purpose of the meeting was to discuss the organization of this new division and to explore the ideas of the persons attending the meeting with respect to the objectives and goals of an engineering division within FPRS. Those attending were: R. M. Garratt, Edward Hines Lumber Co.; R. M. Gooch, Dow Chemical Co.; Don Percival, Small Homes Council, University of Illinois; Eugene L. Bryan, University of California Forest Products Laboratory; Arnold P. Schniewind, University of California Forest Products Laboratory; John R. Neetzel, Great Lakes Forest Experiment Station and School of Forestry, University of Minnesota; R. L. Youngs, U. S. Forest Products Laboratory; and John Drow, U. S. Forest Service, Washington, D. C.; R. J. Hoyle, Potlatch Forests; and J. D. Snodgrass, Oregon Forest Research Laboratory.

Activities

A description of the proposed activities for an engineering division as set forth in the division officer's manual was read to the membership present. The question of the scope and objectives of the division were open for discussion and passed around the table. Some of the comments from the floor were as follows. Although other societies provide some outlet for information on the engineering uses of wood, there still is considerable need for a forum of this type. Another comment was that the name, Engineering Division, might be misleading. This viewpoint was rather general among the group assembled, and consideration was given to a change in the name. It was proposed in the form of a motion passed and seconded and unanimously voted upon to use the name "Wood Engineering Division." One of the members felt that an Engineering Division would serve well for the discussion of research and papers dealing with the construction and design of agricultural buildings. The idea was further elaborated upon, and it was pointed out that the division could perform a service in the publication and release of information on

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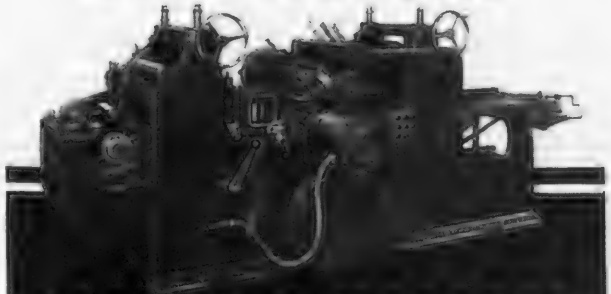

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wood to engineers. It was urged that the function of the division be kept somewhat general and that we avoid dealing with specific designs or papers of a too highly applied nature. The opportunity to improve the position with which wood is held as an engineering material in the minds of executive members of engineering colleges was brought forth.

It was recognized that considerable work has been expended by members of other organizations, such as National Lumber Manufacturers Association and the American Institute of Timber Construction, in correcting this situation. However, it was felt that additional effort would be welcome to this end. Another member of the assembled group indicated that extensive changes in methods of home building were imminent and that an engineering division would serve a very useful purpose in helping to facilitate improvements of this kind.

The idea was expressed that this division may take up the subject of mechanical properties of wood at the point where the fundamental properties and anatomy division leaves off. It should deal particularly with the subject of improving the ability of the engineer to use wood to design with wood and to have confidence in reliable engineering information published on wood. It was suggested that the division should limit its activity to some reasonable series of objectives, particularly during this first year, which would be somewhat organizational in nature. A motion was proposed that a wood engineering division be definitely established to serve as a forum for discussion of material relative to the use of wood. The motion was seconded, voted upon, and carried.

A second motion was proposed that the name of the division be altered to "Wood Engineering." This motion was seconded and carried. The members meeting at this business session agreed to serve as a steering committee during this first year of organization. It was next decided to elect a chairman and vice chairman. Nominations were presented and the temporary officers previously named were elected to serve during this first year.

1962 Meeting

It was proposed that a program be organized for the 1962 meeting of this division. Members present agreed that this should be done. After some discussion, it was decided that only one technical session be requested for the following year. Discussion was then held regarding the notification of the many other persons in FPRS who will be interested in this division. It was decided that suitable notices inserted in the *Forest Products Journal* and a letter from the chairman to a list of FPRS members and possibly others which would be made up by all members of the steering committee during the next 60 days would be suitable message for publicizing the new division. The steering committee will also make suggestions on a program (matur) for the 1962 meeting. The chairman and vice chairman were charged with the responsibility of programming for the 1962 meeting.

It was suggested further that announcement of the formation of the division be transmitted to the American Institute of Timber Construction, the National Lumber Manufacturers Association and perhaps to other association groups who could pass along this information to their members. It is not the purpose of this new division to compete with the activities of other engineering associations but to serve the members of FPRS and their engineering interests and to supplement wherever possible the activities of other organized technical groups dealing with wood as an engineering material.

Marketing Division Discusses 1962 Meeting

The meeting was called to order at 4:45 p.m., June 20, 1961, by Acting Division Chairman William B. Lloyd of Michigan State University. Minutes of the last Annual Meeting were not available for presentation at the meeting.

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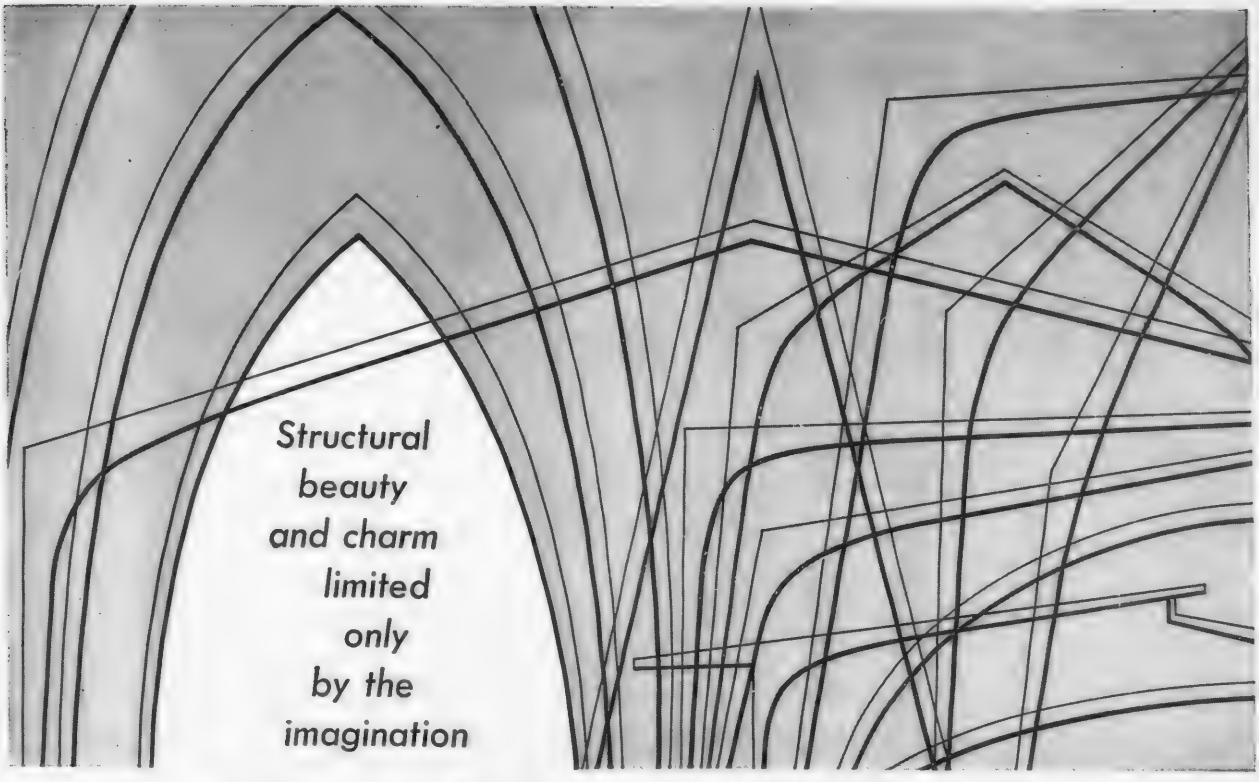

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Church in Conover, N.C.– Bonding adhesives–Penacolite. Arch span varies from 37'3" to 97'10". Roof pitch varies per foot from 34-27/32" at one end to 4-5/8" at the other.

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Dierks Forest Company Office Building, Hot Springs, Arkansas–Penacolite adhesives were used in this modern office building in laminated timbers.

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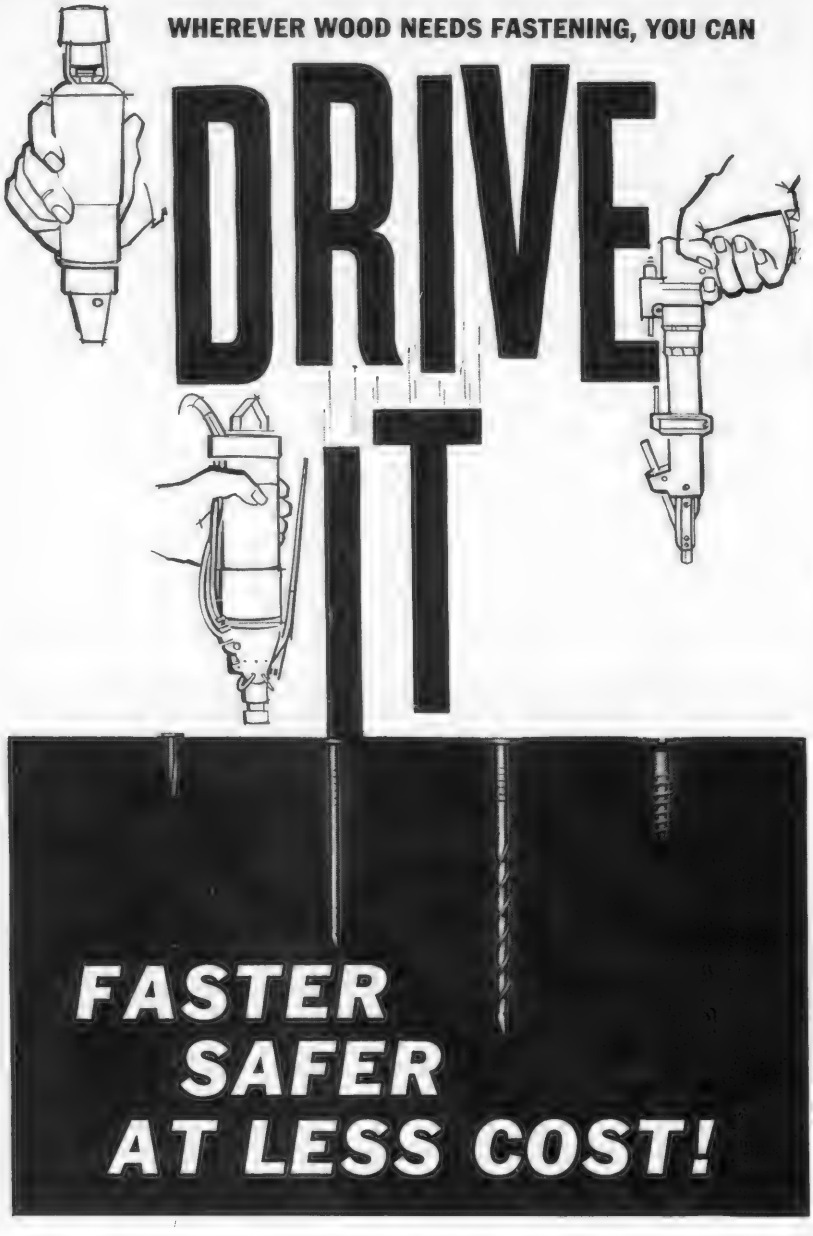

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1962 Meeting

Discussion ensued regarding operations of the division during the past year. Plans relative to a Technical Marketing Session at Spokane in 1962 were discussed. Suggested topics for papers for this meeting were:

Interrelation of product development and marketing, marketing research versus sales policies, and a panel discussion.

Officers

Karl Bollerslev, Boise Cascade Corporation, Emmett, Idaho, was elected as the Division Chairman for 1961–62. The Vice Chairman will be Professor William H. Reid, Division of Forestry, West Virginia University, Morgantown, West Virginia. It was decided that the Division Chairman would select his Program Chairman.

Attendance

Those in attendance at the business meeting were: Dr. Ben S. Bryant, Director Institute of Forest Products, College of Forestry, University of Washington, Seattle 5, Washington; O. G. Sherman, Jr., Masonite Corporation, 111 W. Washington Street, Chicago 2, Illinois; Professor W. H. Reid, Division of Forestry, West Virginia University, Morgantown, West Virginia; and William B. Lloyd, Professor, Department of Forest Products, Michigan State University, East Lansing, Michigan.

Mechanical Conversion Division Renames Subdivision

The Mechanical Conversion Division was approved at the meeting of the membership of the Society at the Annual Meeting in Montreal in June, 1960, and had combined the original Sawmilling Committee and Wood Machining Committee.

At the first meeting of the new Division, it was decided to create 2 subdivisions: 1) Manufacturing Methods, Mr. John K. Barrow, Jr., Chairman; and 2) Wood Machining, Mr. Norman C. Franz, Chairman. Mr. Charles W. McMillin was elected Secretary of the Division.

Mr. Barrow, Chairman of the Manufacturing Methods Subdivision, conducted a survey of new equipment and development in the sawmills across the country and, based on the reports, has prepared an excellent review of the sawmilling industry which was printed in the *Journal*.

At the meeting in Montreal, the Wood Machining Subdivision decided to continue publication of the Wood Machining Abstracts, which were so successful in previous years. However, due to the very heavy work load of

the Chairman of the Committee, the Subdivision was unable to carry this out. At the Annual Meeting the Committee was reactivated, and it is hoped that the Wood Machining Abstracts will be published again.

Questionnaires

In the beginning of the year, the Executive Secretary, Mr. Kenneth E. Huddleston, arranged for a mailing list to members by Division affiliations and this enabled us to send out a questionnaire to all the members who indicated an interest in belonging to our Division. Out of the 461 Questionnaires, 78 replies have been received.

The majority of the members replying have indicated an interest in the work of both Subdivisions. The important part of the survey was the large number of members' suggestions and remarks, as well as a number of papers by authors and subjects suggested by the membership. This will enable the officers of the Division to prepare at an early date a very good program for the next Annual Meeting.

The by-laws of our Society provide for the Division Chairmen to nominate one member in each section to act as a liaison between the section and the Division. We found it very difficult to carry out this provision during the last year, not having a full list of members of the Division divided by sections. However, with the help of the new list mentioned previously in this report, and the result of our questionnaire, I hope to be able to arrange for close co-operation between our Division and all the sections, through the liaison members to be nominated shortly.

At the Annual Meeting of our Division in June, 1961, the membership decided to change the name of the Manufacturing Methods Subdivision to Lumber Manufacturing Subdivision. The same officers were elected for another year.

Particle and Fiber Process Evince Interests in Other Divisions

The meeting was presided over by Arthur Mottet, Chairman, and was attended by 40 affiliates of the division. The chairman reviewed the objectives of the division as developed by a special national committee and accepted by the Executive Board of the Society.

Divisional Questionnaire

In May of this year, Mr. Mottet sent to all Society members, who indicated interest in the division, a questionnaire meant to clarify major interests of the membership and to call for suggestions to improve the program, offer papers, or suggest sources for papers. About 70 replies were received and, on that basis, he reported major interests programwise, in order of preference: 1) particle-board, 2) molded products, 3) hardboard, 4) flakeboard (a certain amount of confusion exists here because, to many people and according to standard definitions, "flakeboard" is a particleboard made from flake type particles), 5) insulating board and fiberboards other than hardboard, and 6) special items including board binders, test methods, product standards, markets and uses, board economics, and production machinery.

In a review of what is desirable to discuss at the business meeting of the division and what is desirable to have the division undertake during the present year, answers indicated the greatest interest in testing methods and board product standards. Some affiliates even suggested that the division issue standard test methods. One recommended that the division set up an organization for policing product quality.

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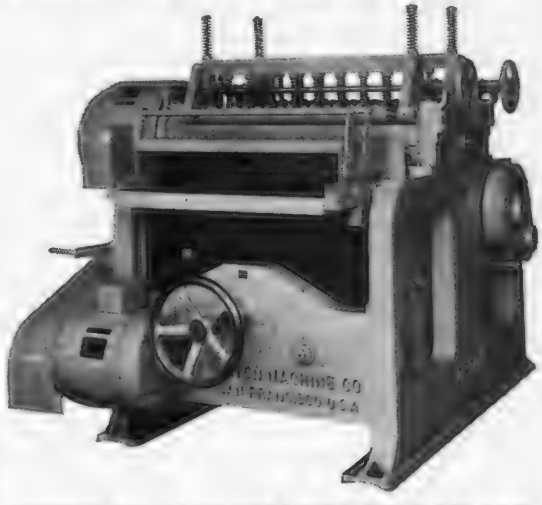

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Other Interests

Others expressed the desire to direct activity in the need for tests and application of boards in exterior service. Compilation of information pertinent to molded products, board binders, use of bark, market information, application of statistical quality control, and information on production machinery was the indicated interest of others.

Other discussion pertinent to division operation was the sponsorship of technical sessions, steering committee makeup, and section representatives to help the division officers.

A survey was conducted to find out the interest in other divisions; this was done to avoid conflicts in scheduling national meeting sessions. Interest was evidenced in all divisions; however, the highest interest shown was in Division 6, Glues and Gluing, and Division 7, Treatments and Coatings.

Business

The group accepted and passed a motion that the author of a technical paper for presentation at a national meeting from this division be required to submit four (4) extra copies of the paper to the division chairman. He would then send them to division members prior to meeting for headlining questions for the discussion period. If screening indicates that the paper is acceptable for presentation the author will be requested to supply 100 additional copies at the time his paper is presented.

The officers, Arthur Mottet, Chairman, and Wayne Lewis, Vice Chairman, were re-elected for another term.

Drying Division Discusses Projects

The first order of business was that the minutes, the reading of the minutes be dispensed with. The next order of business was a report of a News Digest Subcommittee (Chairman Harvey Smith, in absentia) given by Eric Ellwood.

A report on Kiln Clubs was read by Ray Rietz in the absence of the chairman, E. Rassmussen. In the discussion that followed a question was brought up by Hopkins as to the activities of the Kiln Clubs. Mr. Rietz answered that all clubs had been active, and that only joint meetings were reported per se in the written report. One correction was brought up by Gatslick: that the eastern part of New York be changed to western relative to a need for increased Kiln Club activity. The report was accepted.

Wood Moisture Subcommittee

The third order of business was a report from the Wood Moisture Subcommittee. Chairman J. Bethel was not in attendance, and an oral report was given by Mr. Rietz. The Wood Moisture Subcommittee relates to work involving moisture content in use. There is a research grant and project now under the direction of the Forest Service relating to national environment which will include data on moisture content in use. A group leader at the Forest Products Laboratory has been assigned, and a working plan is being prepared.

Rietz reported that the work that H. Smith has done in conjunction with the California Laboratory had been completed in part and published. E. Ellwood reported that additional work on interior moisture content studies was in progress. Hopkins reported that additional work is in progress in Louisiana. Ellwood questioned the value of continuance of the committee in view of the Forest Service environmental research project. Page reported that the Southeastern Station is now doing work on a 2-year project in buildings. Hoffman said that he is interested in better coverage particularly in southern Florida. Rietz pointed out that the experiment stations will undoubtedly be involved in the work and will require the aid of Dry Kiln Clubs, schools, etc., and that he hopes that the breadth of the study will include schools, and churches, but that furniture plants, if considered, would be way down the list in the overall environmental study.

Wood Drying Movie

The next order of business was the Wood Drying movie. John Zerbe, the chairman, was not present and a verbal report was given by Dr. Christian Scar of the College of Forestry at Syracuse. He reported that the 22-minute educational film on the mechanics of wood drying should be ready by the next annual FPRS meeting. It includes animated and time lapse photographic techniques and much work has already been completed. The level of the film is primarily for student instruction, but it is also hoped that it will have television potential.

After this, the annual status of wood drying report was given by Eric Ellwood, the chairman. He gave an informal oral report. The status report itself was published in a recent *Journal*, and the work was compiled by some 23 correspondents including a number of people overseas. The idea was to give a broad international coverage and a broad bibliographic survey of work in the drying field. He wanted the membership to consider what they might like to do in the future. He suggested that interim reports might be in order with a more complete report every few years.

Rietz reported that in the discussion with K. E. Huddleston, Executive Secretary, that it had been suggested that status reports be spread out over a period of 12 months for the different divisions which would improve the sales appeal of the *Journal*. Dickinson said that he thought that the annual review report should be earlier in the fall than it has been in the past; therefore, status reports would be due earlier than in the past. Mr. Preston suggested that it might be of value to give reports in specific areas such as predryers, for 2 or 3 years and a full report, for example, every fifth year. It was moved by Ellwood and approved that interim reports, augmented by broad full-coverage reports every few years, be effected for the status of drying committee with the chairman to decide the specific area to be covered.

New Business

Mr. Rietz said that he thought such papers as Dr. A. J. Stamm and himself had given in other division meetings could very well have been given in the Drying Division meeting. He commended Eric Ellwood for the fine status report and the breadth of the report that had been published in a recent *Forest Products Journal*. He also said that the quality of the reports in the past had been excellent. He re-emphasized the opportunities of the division to supply basic fundamental papers as well as applied phases including new methods and equipment.

Chairman Millet suggested that a permanent secretary be assigned to aid new chairmen and vice chairmen on procedures of the Society as well as to inform them on background material so that there would not be duplication and that things could be run at maximum efficiency. Eric Ellwood suggested that rather than permanent, perhaps the secretary could be assigned for a period of 2 or 3 years.

New Officers

The report from the nominating committee and the appointment of the new division officers for next year was given. They are: Chairman, Edward Conway, Conway Corporation, Grand Rapids, Michigan; Vice Chairman, David Lowry, Inter-Mountain Forest and Range Experiment Station, Missoula, Montana; and Secretary, Charles Cozlick, Oregon Forest Products Laboratory, Corvallis, Oregon.

Mr. Rietz brought up the need for a program chairman for the meeting to be held two years ahead so that papers and other preparations could be properly handled. In view of the fact that the next meeting following the Spokane meeting will be held in New Orleans, he called on Hopkins as to his recommendations. Hopkins recommended and it was approved that Jake Hauptman be assigned as the program chairman.

Timber Production

The meeting was called to order by Chairman J. A. Doyle, at the Kentucky Hotel, Louisville, Ky., at 3:00 p.m., June 20, 1961.

Activities

The Chairman reported that during the past year a questionnaire requesting members' views on future activities of the Division had been prepared and sent to all those who had expressed a subject matter interest in the Division. The questionnaire had been sent to some 353 individuals, and, on the whole, the response had been less than satisfactory. Although only about 10 percent of the questionnaires had been returned, there were received, however, some interesting and thoughtful replies. Several had suggested that a thorough list of references or supplemental bibliography on logging articles be published in the *Forest Products Journal* at the time of the Annual Review of the Timber Production Division in the February issue. There was general agreement that this should be attempted, and it was further suggested that consideration should be given to the keeping up to date of the preliminary bibliography on logging prepared by the U. S. Department of Agriculture for the 10 years preceding 1957. It was agreed that the latter proposal would be difficult for the Division to undertake.

The Chairman reported that as a result of correspondence between the Division and the various sections, some eight or nine section representatives had been appointed to the Division Steering Committee. Mr. Doyle agreed to follow-up this matter with a view to having representatives from all sections on the Steering Committee.

There was considerable discussion regarding the scheduling of both the Technical Session and the Business Meeting of the Division. It was noted that the Technical Session was being held on the last afternoon of the Meeting and conflicted with some of the scheduled tours in the Louisville area. It was also agreed that in future the business meetings of the Mechanical Conversion Division and the Timber Production should not be held concurrently because of similar interests of those interested in these two Divisions. A closer liaison between the Technical Divisions and the Executive Board was recommended in this regard.

Technical Session

The Vice Chairman, J. W. Lehman, was congratulated for his efforts in organizing an excellent program for the Technical Session at the Louisville Meeting. It was unanimously agreed that the Division hold a technical session at the Annual Meeting in Spokane in 1962. Professor George Stenzell, of the University of Washington was appointed program chairman.

Nominating Committee

Fred C. Simmons, Chairman of the Nominating Committee, presented the following slate of officers for the coming year: *Chairman,* J. A. Doyle, Head, Wood Utilization Section, Ottawa Laboratory, Forest Products Research Branch, Department of Forestry, Ottawa, Ontario; *Vice Chairman,* Prof. George Stenzel, Faculty of Forestry, University of Washington, Seattle, Washington; and *Secretary,* E. F. Landt, Rocky Mountain Forest & Range Experiment Station, School of Mines Campus, Rapid City, S. D.

The slate was unanimously approved and the Chairman was instructed to recommend it to the Executive Board.

In view of the necessity of arranging the details for the Technical Session very early in the year for future Annual Meetings, it was recommended that consideration be given to the appointing now of a program chairman for the Division for the Annual Meeting in New Orleans in 1963. Bruce Mety of the Mid-South Section was the unanimous choice of those present and the Chairman was instructed to appoint him 2nd Vice Chairman, and Division Program Chairman for the New Orleans Meeting, if he is willing to accept the assignment.

Attendance

The meeting adjourned at 4:10 p.m. The following were present: O. A. Schmidt, Pennsylvania State University, University Park, Pa.; F. C. Simmons, Northeast Forest Experiment Station, Upper Darby, Pa.; B. M. Granum, Iron Range Resources & Rehabilitation, State of Minnesota; E. F. Landt, Rocky Mountain Forest & Range Experiment Station, Rapid City, S. D.; R. H. Page, Southeast Forest Experiment Station, Asheville, N. C.; R. F. Haussman, U. S. Forest Service, Upper Darby, Pa.; John W. Helman, Tennessee Valley Authority, Norris, Tenn.; H. C. Jellicoe, Department of Industrial Development, Winnipeg, Manitoba; J. A. Doyle, Forest Products Research Branch, Department of Forestry, Ottawa, Ontario; W. J. O'Neil, University of Missouri, Columbia, Mo.; Richard West, Rutgers University, New Brunswick, N. J.; T. S. Veazey, President Elect, F.P.R.S.; Fred Dickinson, Vice-President, F.P.R.S.; Ben Bryan, Institute of Forestry Products, Tacoma, Wash.; and Bill Finan, Mobile River Sawmill Co., Mobile, Ala.

Chemical Conversion Suggest Future Topics

The Chemical Conversion Division had its business meeting and elected the following officers for the coming year: Jerome E. Saeman, Chairman; Franklin W. Herrick, Vice Chairman, and J. B. Doughty, Secretary. The work of the annual review committee and of the news release committee was reviewed and commended. These efforts are to be continued.

Suggested topics for future programs included a symposium on bark utilzation for 1962 and one on naval stores for 1963. It was suggested also that each meeting include a panel discussion of recent advances in chemical conversion.

Production Management States Objectives

Consensus of opinion at the business meeting of Division 10, Production Management, was that the objective of the division was to epitomize the philosophy of management in the forest products industries. This feeling was so strong that the group proposed to recommend to the FPRS Executive Board that the division title be changed from "Production Management" to simply "Management."

This philosophy was tied into discussion of topics for possible presentation at the next annual meeting as the following subjects were considered: production control, communications, cost control, new equipment evaluation, labor relations, relationship of quality control to management, maintenance, and prognostication of future processes and products. Various methods of presentation were discussed with general agreement that floor discussion should play an important part.

Officers

The following were elected division officers: Chairman, J. J. Allegretti, Scott Lumber Co., Burney, Calif.; Vice-chairman, George Vasiliou, Forest City, N.C.; and Secretary, Wyman Williams, Jr., Columbia Hardboard Co. Everett, Wash.

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1962 Annual Meeting
General Chairman—R. Jones

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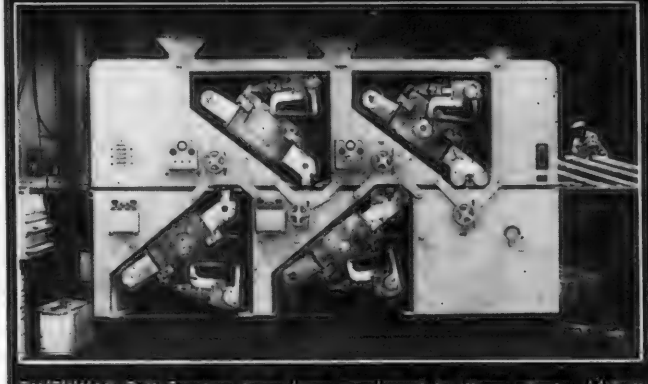

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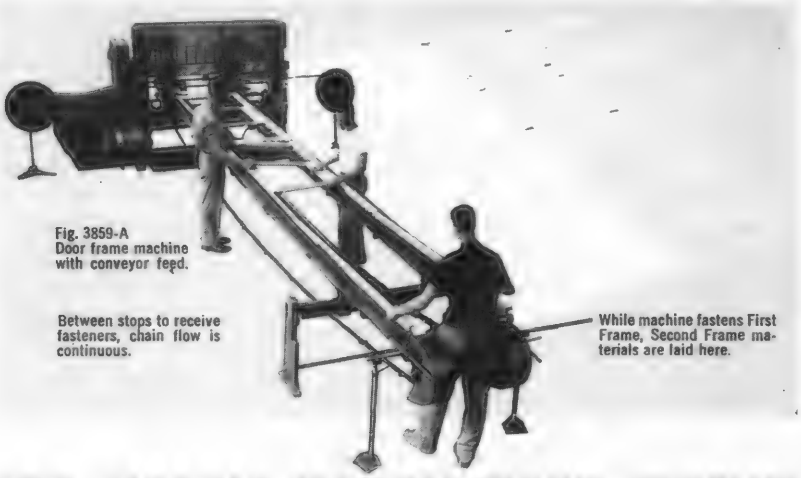
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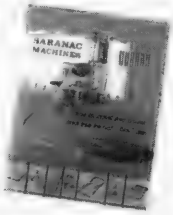

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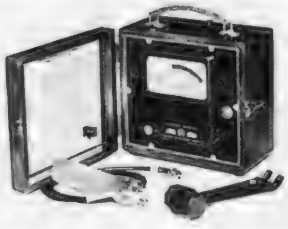

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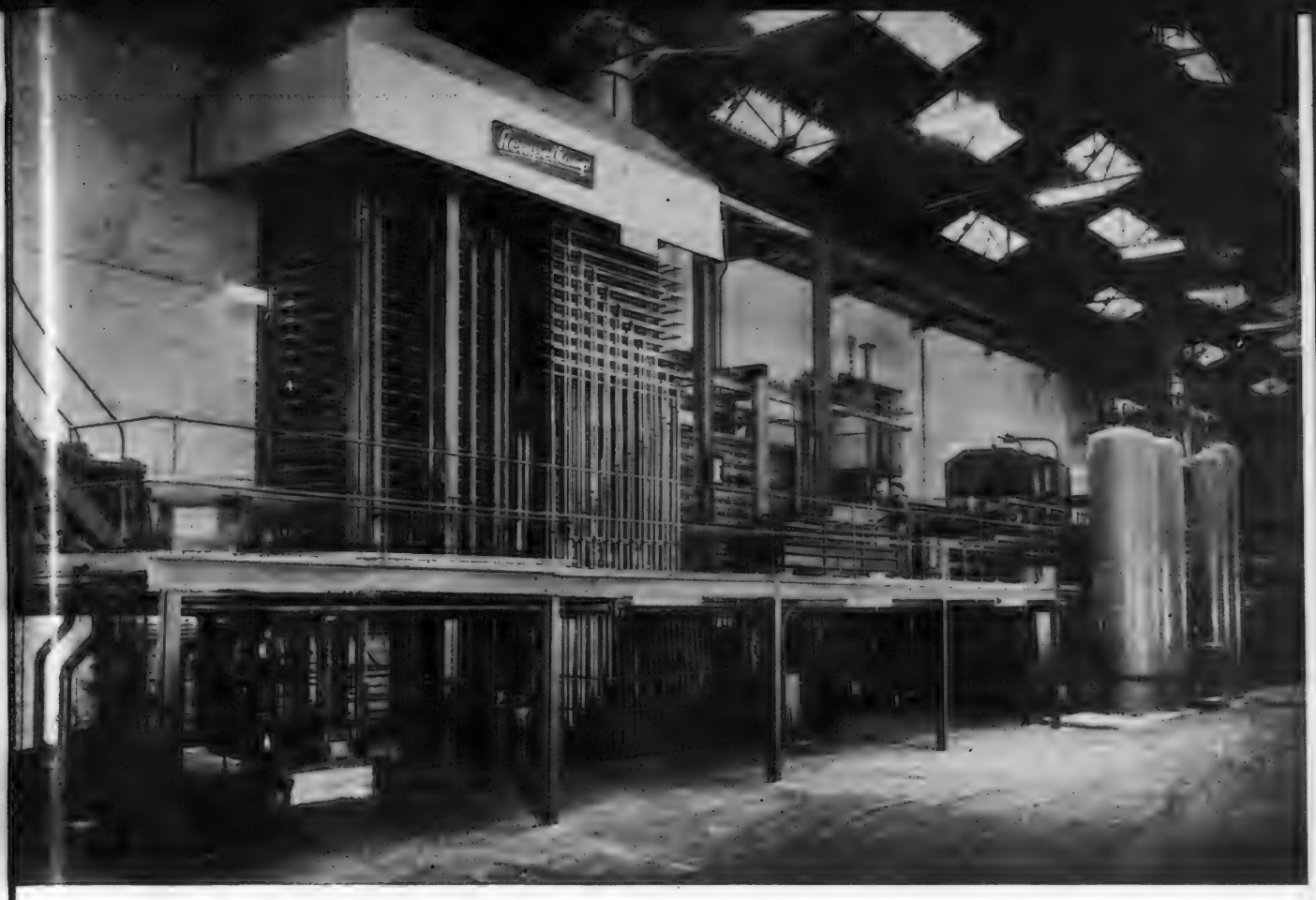

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Publications Committee to Revise Review System for Journal Papers

The Publications Committee has recommended to the Executive Board that the procedures used for reviewing papers considered for publication in the *Journal* be revised and strengthened.

The revised procedures will contain more explicit instructions to reviewers, and an attempt will be made to define types of articles into possible classifications, such as research, technical, semitechnical, and production. One essential feature to be emphasized will be that papers —other than review papers—contain *new* material. Other criteria will include the timeliness of general papers and the long-term reference value of research and technical papers.

Editorial Balance

In his report to the Committee, John McDonald, editor, reviewed the material published in 1960 and stated that, in his opinion, technical information constituted 41 percent of the material published; semitechnical and production information, 38 percent; and news and service information, 21 percent.

He also presented an analysis that showed a very close relationship between editorial balance and the division interest survey—a strong expression of division interest was reflected by a relatively higher percentage of material published on topics of interest to that division.

The committee discussed the methods by which the editor classified material. Although his system was based on arbitrary decision, the group felt he was making a sound approach to the problems and recommended he continue until definitions of the types of material desired could be established. It was decided that the chairman appoint a subcommittee to draw up such definitions.

Production Articles

The group discussed the possibility of including more production-type articles in the semitechnical material. The editor pointed out that he was, in general, restricted to the material submitted to him or presented at the various meetings, and that, at present, lack of time prevented him from soliciting such material.

It was recommended that the analysis of division coverage be continued and that the committee check with the divisions to see whether their subjects were adequately covered. This could be a possible source of more production-type articles.

Report to Board

The consensus of the members was drawn up in the following statement, which was presented to the Executive Board:

"It is recommended that the present balance of material be maintained, with the proportion of non-technical and news material being held at a level necessary to maintain advertising revenue, so that the *Journal* can publish a maximum possible number of technical papers at no increase in cost to its membership."

Other Business

The editor has been instructed by the Executive Board to revise the booklet "How to Write for FPRS." The committee will assist the editor in this, and it is hoped the proposed classification of material desired for publication will be a useful addition. More guidance will thus be given to potential authors and to officers soliciting material.

It was recommended that short "technical notes" be published in the *Journal,* and the editor was instructed to solicit such material.

It was generally agreed that the abstract section of the *Journal* should be strengthened, and it was recommended that the editor adopt a long-range objective of improving and expanding this section.

A question was raised whether the lengthy literature citations frequently published in the *Journal* should be continued. It was agreed that such lists were a valuable tool to membership and they should be continued.

The committee agreed that articles should be rejected if they contained promotional material or did not present new information.

Committee Renamed

Dr. H. O. Fleischer has been renamed Chairman of the Publications Committee. *Journal* Editor John K. McDonald, and Executive Secretary Kenneth E. Huddleston are ex officio members. The following are the members of the Publications Committee: E. A. Behr, Michigan State University; D. L. Brink, University of California Forest Products Laboratory; Ralph Bescher, Koppers Co., Inc.; R. L. Hiller, American Cyanamid Company, Chicago, Ill.; J. B. Huffman, University of Florida; H. B. McKean, Potlatch Forests, Inc., Lewiston, Idaho; A. D. Syska, The Crossett Co., Crossett, Ark.; R. W. Wellwood, University of British Columbia; and W. I. West, Oregon State College.

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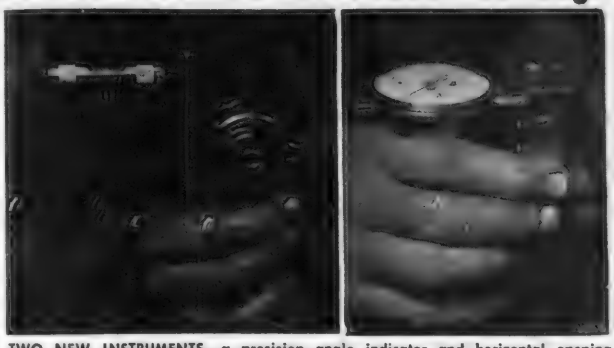

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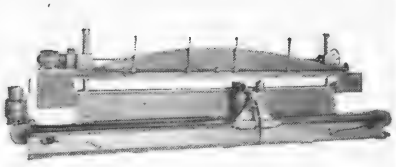

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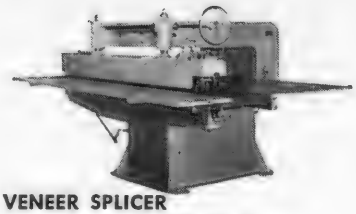

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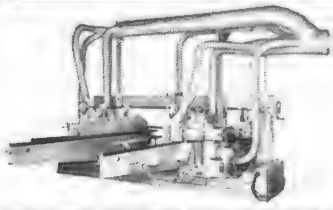

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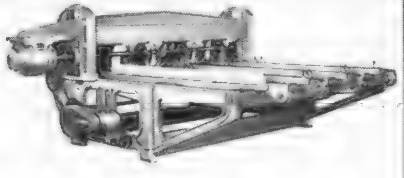

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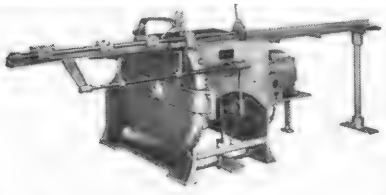

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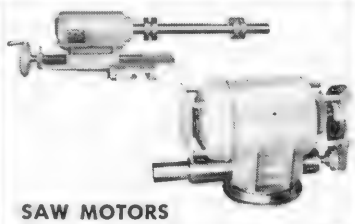

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FOREST PRODUCTS JOURNAL VOL. XI, NO. 9 SEPTEMBER, 1961

effect of temperature and moisture content on:

Internal Friction and Speed of Sound in Douglas-fir[1]

WILLIAM L. JAMES
Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

IN RECENT YEARS, CONSIDERABLE INTEREST has developed in the possibility of determining strength properties of wood through nondestructive vibration tests. The basic idea has been that the speed of sound, the internal friction, or combinations of these with other factors may depend in a measurable way on the same fundamental quantities that determine the strength properties of the wood. Development of such nondestructive test methods has shown some promise, but the work has been handicapped by incomplete basic information on the vibration properties of wood and by a lack of a suitable theory that interprets the vibration properties of wood in terms of more basic properties.

The vibration properties, especially internal friction, in metals have received considerable theoretical treatment, but the theory of internal friction in solid dielectrics is not as well developed. No available theory interprets the internal friction of solid dielectrics in terms of fundamental structural properties, while describing the observed dependence of internal friction on temperature and frequency. A complete theory of internal friction in wood, with the additional variable of moisture content, remains virtually nonexistent.

A limited amount of interesting experimental information has been obtained on the vibration properties of wood, and some attempts have been made to interpret the results theoretically. The effects of frequency and moisture content have been studied, both separately and in combination, but no data were found that covered a range of frequency, moisture content, and temperature.

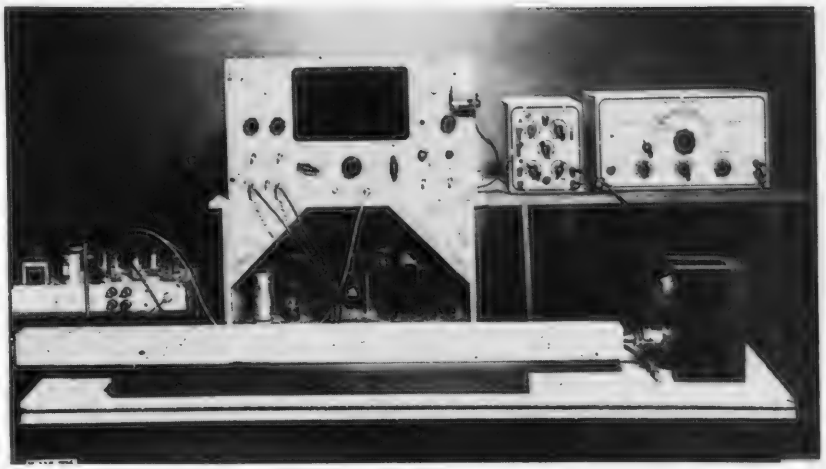

Fig. 1.—General view of apparatus for measuring log decrement and frequency of free vibration in wood specimens.

Krueger and Rohloff (1)[3] studied the effect of frequency on the vibration properties of wood, but did not determine the influence of temperature and moisture content. They reported that the elastic constants and the internal friction were independent of frequency for both lateral and longitudinal vibration in the sonic range and that this was in agreement with the fundamental theory of Boltzmann. This result is in agreement also with results obtained by others on other dielectrics (2). By contrast, Wuolojoki (3), Pentoney (4), Ptacnik (5), and Fukada (6) all found some degree of variation in internal friction with frequency. Later Kollmann and Krech (7) observed an increase in internal friction in spruce sticks in free lateral vibration as the length of the stick was progressively reduced so as to give a progressively higher frequency. This increase in internal friction with frequency disappeared, however, when the lateral dimensions of the sticks were reduced in proportion to the reduction in length. The increase in internal friction as the specimens were shortened without changing the cross section was attributed to the increasing effect of shear under these conditions, since Narayanamurti (8) found the internal friction in torsion, where shear stress predominates, to be nearly four times as large as the

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 1, Division 1 (Anatomy and Fundamental Properties), June 19, 1961.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to Literature Cited at the end of this report.

The log decrement and natural frequency of free longitudinal vibration in Douglas-fir bars were measured over a range of temperature and moisture content. Natural frequency decreased both with increasing temperature and with increasing moisture content, but values of log decrement showed minimums at various combinations of temperature and moisture content.

internal friction in bending. This same increasing effect of shear would be expected, at least qualitatively, when a bar is caused to vibrate laterally at progressively higher modes. This could explain why Fukada (6) obtained equivalent results when the frequency was varied by varying the length of the specimens and by using higher modes of vibration.

A somewhat analogous effect could be expected in the case of uniform bars vibrating longitudinally; in this case, transverse stresses develop that have negligible influence only when the wave length of the vibration is much larger than the maximum lateral dimension. Therefore, as the frequency is increased in longitudinal vibration, either by shortening the specimen or by exciting higher modes, unless the lateral dimensions of the specimens are proportionately reduced, the damping due to transverse stresses would become increasingly important. As shown by several investigators, (Pentoney (4)) the internal friction for stress perpendicular to the grain is larger than that for stress parallel to the grain; therefore, wood specimens in longitudinal vibration parallel to the grain should show an increase in apparent internal friction with increasing frequency.

The variations of the internal friction in wood with moisture content and temperature have not been studied extensively, and data showing the interrelation of these variables are particularly scarce. Kollmann (8) and Fukada (6) studied the internal friction at various temperatures and moisture contents but obtained data over a range of temperature only for ovendry specimens. Conversely, Kollmann and Krech (7) and Pentoney (4) obtained data over a wide range of moisture content but at just one temperature.

Basic data on the internal friction in wood as a function of temperature and moisture content is presented here with the objective of covering combinations of the two variables over the widest limits easily attainable. Perhaps when complete experimental data are available on the effect of temperature, moisture content, and frequency on internal friction in wood, a realistic theory may be developed to interpret these results and serve as a guide to develop a workable nondestructive test for the strength of wood.

Experimental Descriptions

Specimen Preparation: Specimen material was selected at random from several freshly cut, green Douglas-fir logs, and 200 rough-sawn bars were prepared, 2¼ inches square in cross section and 40 inches long. The material was end coated as soon as it was cut to length and placed on stickers in a room at 80° F. and 90 percent humidity in order to dry the material somewhat below the fiber-saturation point. After about 2 months, 40 of the rough bars were placed into each of five controlled temperature and humidity rooms to be conditioned. These conditioning rooms were at 80° F. with relative humidities of 30, 65, 80, 90, and 97 percent, giving equilibrium moisture content values in the order of 6, 12, 16, 20, and 28 percent, respectively. After the material had been in the conditioning rooms about 6 months, the moisture content of each group had approached to within about 1 percent equilibrium, as measured by a resistance-type moisture meter. At this time, the rough specimens were carefully dressed to a uniform square cross section 1⅞ inches on a side and trimmed to a length of 39½ inches. The finished specimens were then weighed and returned to the humidity rooms for final conditioning. After a few specimens in each room had shown no significant weight change in two successive weekly weighings, all the specimens were weighed once a week until they were at essentially

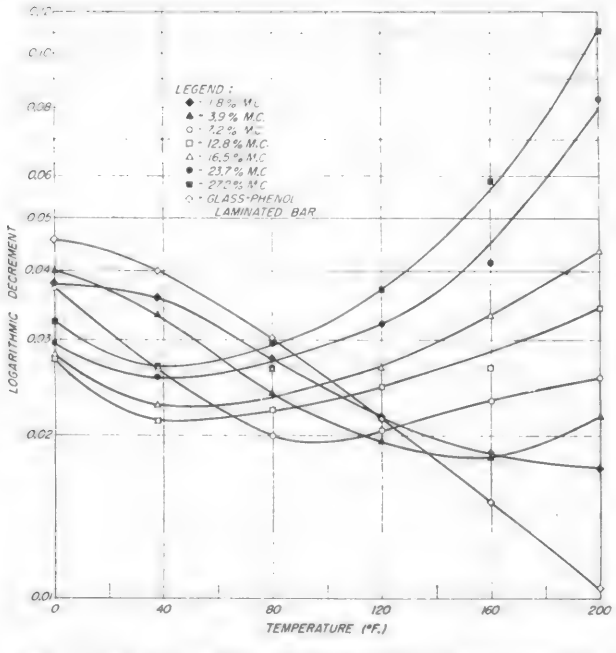

Fig. 2.—Plot of log decrement as a function of temperature at different levels of moisture content.

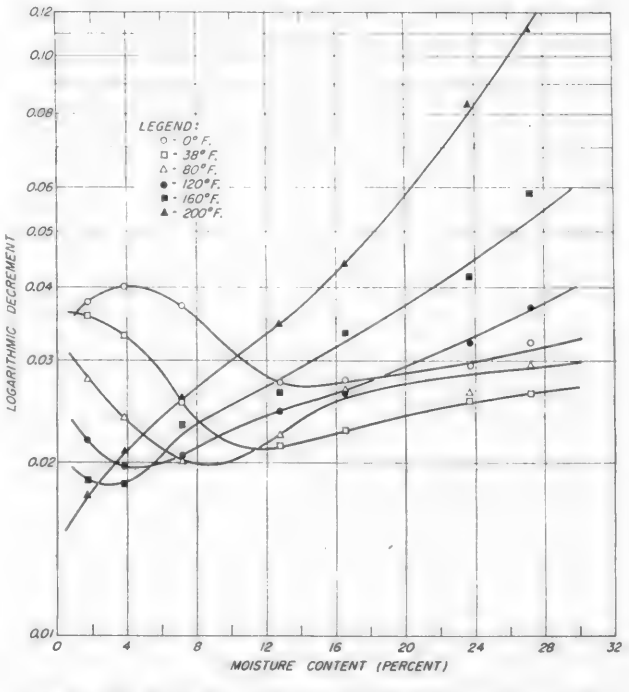

Fig. 3.—Plot of log decrement as a function of moisture content at various temperatures.

constant weight. The entire conditioning period was about 10 months.

Previous to the vibration experiment, each specimen was balanced on a central support and the center of gravity marked prominently on the specimen. This made it easy to balance the specimen quickly in the measuring apparatus.

Apparatus: *Conditioning:* Initially, the specimen material was conditioned to one of five moisture content levels in controlled humidity rooms at 80° F. To condition the specimens to other temperatures at the same moisture content, they were placed in a metal box with a gasketed door that was located in an environment of the desired temperature. The specimens were supported on shelves, and the door was at the end of the box, thus permitting the specimens to be removed and replaced one at a time. The volume of the box was only slightly larger than that necessary to hold the required 40 specimens at one time, so the humidity inside the box could be expected to come to equilibrium with the specimen material without excessive change in the moisture content of the specimens. For extremes in moisture condition, space inside the box was provided for desiccants or salt solutions for humidity control, and provision was made to inject steam into the box. Temperatures below normal room temperature were attained by placing the box of specimens into either a room maintained at 38° F. or one maintained at 0° F. Higher temperatures were attained by locating the box of specimens in a small dry kiln in which temperature and humidity could be controlled over a wide range. Details on the use of these facilities for attaining various conditions are covered later .

Vibration measurements: The apparatus for measuring the frequency and logarithmic decrement of the vibrations is described in detail in a previous report (9) and shown in Figure 1. Briefly, the specimens were supported at midlength on a small foam-rubber cushion and set into longitudinal vibration, either by a single blow from a small wooden mallet, or by an electromagnetic transducer tuned to the natural frequency of the specimen. The amplitude of the vibration was detected by a microphone whose output was amplified and sent either to an electronic counter and timer for frequency determination or to a special amplitude discriminator. The discriminator determined the logarithmic decrement by counting the number of vibrations experienced by the specimen as the amplitude of vibration decayed by a factor of e, the base of natural logarithms. The logarithmic decrement then was the reciprocal of the number of vibrations counted.

A cathode ray oscilloscope was used to obtain a qualitative indication of the decay pattern for log decrement measurements, and only data associated with smooth regular patterns were recorded.

Calibration: The calibration of the electronic counter used for frequency measurements was based on a stable crystal oscillator that rarely needs correction. Secondary circuits vital to the accuracy of the device could be checked quickly and easily by a built-in self-check feature. Further, the frequency and period of the local 60-cycle power was measured at intervals by the counter to ascertain that it was performing correctly.

Calibration of the amplitude discriminator for log decrement measurements was achieved by measuring the log decrement of vibration of a standard vibration specimen made of glass-fabric reinforced phenolic resin. The log decrement of this phenolic specimen was determined at various temperatures by measurements from cathode ray oscillograms of the decay pattern of its free longitudinal vibration. This standard was kept in equilibrium with an atmosphere at 80° F. and 30 percent relative humidity. When the apparatus to be calibrated was not in an 80° F. environment, the standard was wrapped in insulation while at 80° F. and moved to the location of the apparatus. Here, the insulation was quickly removed and log decrement of the standard determined. The amplitude discriminator rarely needed adjustment, but it was checked in this way before and after each series of measurements.

Experimental Procedure: *General:* The general procedure for measurement of vibration characteristics was to remove a specimen from storage, place it on the foam-rubber support, slide the microphone near one end of the specimen, and quickly tap the other end about 10 times with the wooden mallet. The reciprocal of the log decrement immediately appeared on the electronic counter readout each time the specimen was struck, and the estimated average value was recorded. The specimen was then returned to storage. The specimen could be removed from storage and about 10 replications of the log decrement obtained within a period of 10 to 15 seconds. This was important when measurements were made on specimens in equilibrium with conditions that were intolerable to the measuring equipment; in these cases, the specimens were removed from the condi-

Table 1.—AVERAGE VALUES AND RANGE[1] OF RESONANT FREQUENCY AND RECIPROCAL LOG DECREMENT FOR EACH TEMPERATURE AND MOISTURE CONDITION

Conditioning relative humidity Percent	Moisture[2] content Percent	Specific[3] gravity	Resonant frequency[4]						Reciprocal log decrement					
			0° F. c.p.s.	38° F. c.p.s.	80° F. c.p.s.	120° F. c.p.s.	160° F. c.p.s.	200° F. c.p.s.	0° F.	38° F.	80° F.	120° F.	160° F.	200° F.
10	1.8	0.455	2,825 (818)	2,782 (810)	2,740 (811)	2,712 (808)	2,681 (800)	2,651 (802)	26.6 (12)	28.6 (12)	36.5 (17)	45.4 (27)	54.3 (35)	57.5 (25)
15	3.9	.452	2,809 (816)	2,760 (610)	2,717 (805)	2,686 (799)	2,657 (798)	2,614 (794)	24.5 (12)	30.2 (10)	41.9 (18)	51.0 (22)	55.2 (24)	48.2 (20)
30	7.2	.447	2,739 (798)	2,703 (805)	2,665 (804)	2,621 (796)	2,589 (785)	2,559 (784)	27.3 (11)	38.0 (11)	49.5 (18)	49.1 (20)	43.0 (23)	39.2 (24)
65	12.8	.403	2,741 (492)	2,699 (502)	2,657 (478)	2,620 (482)	2,579 (476)	2,536 (458)	36.7 (11)	47.0 (9)	45.0 (17)	41.1 (16)	37.8 (23)	29.4 (16)
80	16.5	.449	2,683 (584)	2,636 (581)	2,586 (593)	2,530 (599)	2,481 (611)	2,424 (618)	35.9 (20)	43.5 (23)	37.9 (22)	38.7 (20)	30.0 (20)	22.9 (14)
90	23.7	.430	2,514 (674)	2,475 (681)	2,429 (688)	2,343 (724)	2,302 (785)	2,198 (875)	34.4 (18)	39.0 (17)	38.0 (18)	31.1 (26)	23.7 (22)	11.9 (18)
97	27.2	.453	2,476 (484)	2,422 (483)	2,382 (474)	2,279 (446)	2,237 (454)	2,141 (471)	30.6 (18)	38.1 (11)	34.3 (10)	26.6 (15)	16.5 (9)	9.2 (6)

[1]Number in parentheses is range of data giving the corresponding average.
[2]Average of specimens from each group that were not subjected to various temperature conditions, except tow lowest moisture groups where it is average of actual moisture content of test specimens.
[3]Based on volume at test and weight when ovendry.
[4]Normalized to specimen length of 39.5. inches.

tioning environment briefly while the measurements were made.

After the log decrement of each specimen in a group was determined, the equipment was switched to frequency measurement. Frequency measurements were made in about the same way as the log decrement measurements, except that instead of vibrating the specimen with single hammer blows, an electromagnetic transducer driven from a variable frequency source was used to excite continuous vibration in the specimen. The driving frequency was adjusted until the specimen response was maximum and then the frequency was read from the electronic counter and timer. The additional time required for sliding the driving transducer into contact with the specimen and searching for the resonant frequency increased the total time for a frequency measurement to about 20 seconds.

Presumably, the time that elapsed between log decrement and natural frequency measurements for any specimen was enough to return the specimen to equilibrium with the storage condition, since only the surface layer would have changed in the short time required for the log decrement measurement.

Procedure for varying conditions: The specimen material was originally conditioned at 80° F. to moisture content levels of about 7, 13, 16, 24, and 27 percent. For later tests, the material originally at 7 percent moisture content was conditioned to about 4 percent and then to about 2 percent moisture content. A complete set of measurements was made at each moisture level. The general procedure, after establishing a group of specimens at a desired moisture content, was to vary the temperature of the material while maintaining its moisture content, making measurements of vibration properties at the various temperatures.

Because high temperature could cause permanent changes in the physical properties of the wood, measurements at high temperatures were made last whenever this was feasible. The groups of material at the five original moisture levels were tested, in order, at 80°, 38°, 0°, 120°, 160°, and 200° F. The material that was tested at about 4 percent moisture content was dried from 7 percent to 4 percent moisture content at 140° F., and its test temperatures were, in order, 160°, 120°, 80°, 38°, 0°, and 200° F. Finally, this same material was conditioned at about 208° F. to about 2 percent moisture content, and the order of test temperatures was 200°, 160°, 120°, 80°, 38°, and 0° F.

When the vibration test had been completed at all temperatures on the five original groups at about 7, 12, 16, 24, and 27 percent moisture content, the vibration properties were remeasured at 80° F. and the same nominal moisture content. From these measurements it was determined that no permanent change occurred in the material at 7 percent moisture content, and further measurements at lower moisture contents could be made on it.

Based on the first vibration tests at 80° F., and particularly on visual evaluation of vibration decay patterns displayed on the oscilloscope, the specimens from each group that showed unambiguous values of resonant frequency and smooth exponential vibration decay patterns were selected for further vibration tests. Roughly, half of the specimens in each group were so selected.

Ideally, the vibration tests are made in an environment that maintains the temperature and moisture content of the specimen material at the test conditions. This, however, could be done easily only for tests on material at 80° F. and moisture contents of about 7, 13, and 16 percent, by setting up the apparatus in the original conditioning rooms. Specimens at 80° F. and moisture contents of about 24 and about 27 percent were tested in the room at 80° F. and 80 percent relative humidity (giving about 16 percent equilibrium moisture content), since the higher humidity required to maintain 24 and 27 percent moisture content is harmful to the apparatus. The material was carried in the sealed box described in the paragraph on apparatus from its conditioning room to the room where it was tested. The measurements were made in such a short time that no measurable moisture change occurred in the specimens.

Measurements at 38° and 0° F. were made with the apparatus set up in rooms at these temperatures. The specimen material was stored in the sealed box in the cold rooms until temperature equilibrium was attained. This normally required 18 to 20 hours. The temperature of the specimen material was indicated by a thermocouple in the center of a spare specimen that was located near the middle of the box.

As the specimens were cooling, occasional spot checks were made of the weights of a few selected at random. Measurable weight loss occurred in the specimens at 16 percent or higher moisture content, presumably because the cold walls of the box reduced the dew point inside while the specimens were still warm, causing them to dry somewhat. In no case, however, was the indicated change in moisture content considered significant. After the specimens were at temperature equilibrium in these cold rooms, moisture changes were so slow that no further weight change took place during handling and testing the specimens outside the sealed box.

For measurements at 120° F. and above, the specimens were placed in the sealed box, which then was located in a small dry kiln maintained at the desired test temperature. The humidity in the kiln was controlled as nearly as possible to the level that would maintain the specimen moisture content, but for specimens at 16 percent or higher moisture content, it was necessary to inject steam into the box to prevent moisture loss from the specimens at high temperatures.

For these measurements, the vibration apparatus was set up just outside the kiln door. The individual specimens, in order, were withdrawn from the kiln and their log decrement was measured. They were returned to the kiln as quickly as possible. This procedure was repeated in the same order for measurement of resonant frequency. The specimens thus had time between the measurements of log decrement and resonant frequency to recover temperature loss incurred during the log decrement measurement.

For measurement on material at about 4 percent moisture content at temperatures of 120° F. and higher, the previously sealed box was used to contain the specimens, but the box was opened at both ends. A simple set of baffles directed the forced circulation of the kiln through the box, and the kiln conditions of temperature and humidity maintained the desired temperature and moisture content of the specimens. For measurements at 80° F. and lower, the box was again sealed.

For measurements on material at about 2 percent moisture content, the specimens were again placed in the sealed box. The interior of the box was dehumidified by about 5 pounds of anhydrous calcium chloride contained in flat pans that gave a total exposed area of the desiccant of about 3 square feet.

When the vibration tests were complete, the specimens were cut into standard specimens for various strength tests, and two moisture disks were obtained from each specimen. A later report is planned in which the results of the strength tests will be presented.

The Author: W. L. James received his Master's degree in physics from the University of Wisconsin in 1949. He has been on the staff of the U. S. Forest Products Laboratory since 1951, working principally on special problems of instrumentation and in the field of the physical properties of wood.

Table 2.—SPEED OF SOUND AND YOUNG'S MODULUS AVERAGED FOR EACH TEMPERATURE AND MOISTURE CONTENT

Moisture content	Gross[1] density	Speed of sound parallel to the grain[2]						Young's modulus parallel to the grain[3]					
		0° F. 10^5 in. per sec.	38° F. 10^5 in. per sec.	80° F. 10^5 in. per sec.	120° F. 10^5 in. per sec.	160° F. 10^5 in. per sec.	200° F. 10^5 in. per sec.	0° F. 10^6 p.s.i.	38° F. 10^6 p.s.i.	80° F. 10^6 p.s.i.	120° F. 10^6 p.s.i.	160° F. 10^6 p.s.i.	200° F. 10^6 p.s.i.
1.8	0.433	2.23	2.20	2.16	2.14	2.12	2.09	2.16	2.10	2.02	1.98	1.95	1.89
3.9	.438	2.22	2.18	2.15	2.12	2.10	2.07	2.16	2.08	2.02	1.97	1.93	1.88
7.2	.448	2.16	2.14	2.11	2.07	2.05	2.02	2.09	2.05	2.00	1.92	1.88	1.83
12.8	.424	2.17	2.13	2.10	2.07	2.04	2.00	2.00	1.92	1.87	1.82	1.76	1.70
16.5	.488	2.12	2.08	2.04	2.00	1.96	1.91	2.19	2.11	2.03	1.95	1.87	1.78
23.7	.494	1.99	1.96	1.92	1.85	1.82	1.74	1.96	1.90	1.82	1.69	1.64	1.50
27.2	.532	1.96	1.91	1.88	1.80	1.77	1.69	2.04	1.94	1.88	1.72	1.67	1.52

[1]Computed from (SG) (1+MC) (k), where SG is the average specific gravity (column 3, Table 1), MC is moisture content in decimal form, and k converts specific gravity into units of mass per unit volume in a system where inches, pounds, and seconds are the respective units of length, force and time.
[2]Computed from the average length and resonant frequency of each group at each condition.
[3]Computed from the average density and speed of sound of each group at each condition.

Method of analysis: Specimens tested under each combination of temperature and moisture content were treated as a group, the log decrement, natural frequency, speed of sound, and Young's modulus of the individual specimens being averaged for the group. The variation of vibration properties with temperature and moisture content was accurately demonstrated by this procedure, in spite of large differences in properties between individual specimens. This was true because nearly every specimen showed the same variation as the average for the group, even when in absolute value the individual vibration properties were quite different from the average.

The speed of sound was calculated from the equation

$$v = 2fl$$

where f is the resonant frequency and l is the length of the specimen.

Young's modulus was calculated from the equation

$$E = pv^2$$

where p is the gross density of the specimen and v is the speed of sound in the specimen. The gross density was calculated from the weight and volume of the specimen at the time of test. For these calculations, the volume was obtained from the individual specimen length, and the average cross sectional area of its group.

Results and Discussion

Presentation of Results: The reciprocal log decrement and resonant frequency, averaged for each temperature and moisture content, are given in Table 1, and the corresponding average values of the speed of sound and Young's modulus are presented in Table 2. The values of log decrement and resonant frequency at 80° F. for each of the five original levels of moisture content were averaged before and after the material was tested at temperatures up to 200° F. These are presented in Table 3.

The log decrement is plotted in Figure 2 as a function of temperature for each moisture content and in Figure 3 as a function of moisture content for each temperature. Figures 4 and 5 give the corresponding plots of speed of sound as functions of temperature and moisture content. Figures 6 and 7 show the variation of Young's modulus with temperature and moisture content.

Accuracy and Errors: *General:* The chief purpose for collecting the data presented here was to determine the effect of temperature and moisture content on the internal friction and speed of sound in clear Douglas-fir wood. Quantities whose associated errors would probably be significant were temperature, moisture content, and log decrement of free vibration. Quantities whose associated errors were probably too small to affect the data were specimen weight, dimensions, and resonant frequency. Also, because no matching of specimen groups was possible, differences between treatment could be biased by differences in the average basic properties of the specimens in various groups. The magnitude of this effect is unknown, but it appears to be appreciable. The data that show variation of properties with temperature were obtained using the same material for temperatures at a given moisture content, and these data show little scatter. Data that illustrate variation of properties with moisture content, however, were obtained with a different group of specimens for each moisture content (except for 7.2, 3.9, and 1.8 percent moisture content), and these data show considerable scatter.

Temperature: Measurements made at temperatures of 0°, 38°, and 80° F. are probably not affected by error in the temperature of the specimens. These measurements were made in rooms where temperatures were controlled to within ±1° F. There was an uncertainty of ±2° F. in the test temperatures of 120° F. or higher, and the highest temperatures could be as much as 10° F. below the nominal temperatures. The largest uncertainty in the higher temperatures arose from difficulty in holding the dry kiln temperature as its door was repeatedly opened to remove and replace specimens.

Errors in temperature that arose because hot specimens were tested in a room-temperature environment were thought to be insignificant because of the short time required for the measurement. To confirm this, a few specimens at high temperature and moisture content were exposed to the room-temperature environment and tested repeatedly until a significant change was seen. In general, the log decrement did not change measurably until after

Fig. 4.—Plot of the speed of sound in Douglas-fir as a function of temperature for various levels of moisture content.

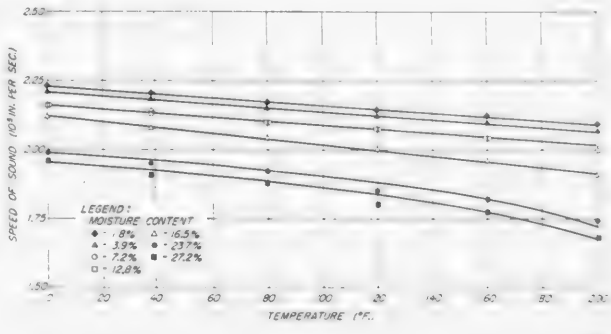

Table 3.—RESONANT FREQUENCY, RECIPROCAL LOG DECREMENT, AND MOISTURE CONTENT AT 80° F. AVERAGE BEFORE AND AFTER TESTING AT TEMPERATURE UP TO 200° F.

Before			After		
Moisture content Percent	Resonant frequency c.p.s.	Reciprocal log decrement	Moisture content Percent	Resonant frequency c.p.s.	Reciprocal log decrement
7.2	2,665	50	5.5	2,679	50
12.8	2,657	45	11.8	2,720	47
16.5	2,586	38	15.0	2,611	39
23.7	2,429	38	22.0	2,435	36
27.2	2,382	34	27.2	2,367	33

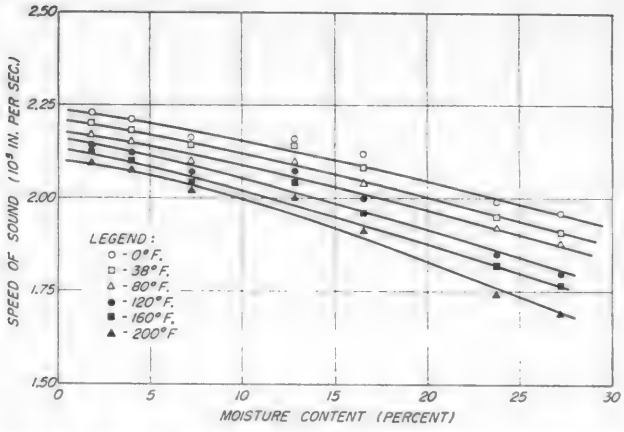

Fig. 5.—Plot of the speed of sound in Douglas-fir as a function of moisture content for various temperatures.

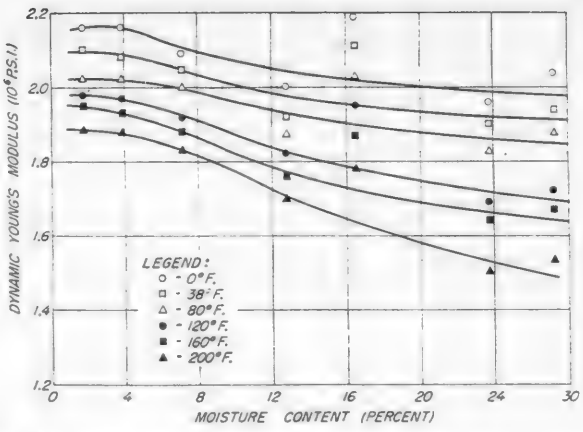

Fig. 6.—Dynamic Young's modulus as a function of moisture content at various temperatures.

about 30 seconds of exposure (about twice the time required for a measurement). The resonant frequency changed continually after the first determination was made (usually within less than 20 seconds after removing the specimen from the conditioning chamber), but generally the change in resonant frequency was less than 0.5 percent after about 45 seconds of exposure to the room conditions.

Moisture content: Errors in moisture content became significant under conditions of high moisture content at high temperature because of difficulty in maintaining equilibrium conditions. At temperatures of 120° F. and below, it was possible to keep the weight of the specimens constant within such limits that the change in moisure content from the original equilibrium condition was not more than 0.5 percent. At higher temperature and moisture content levels, the uncertainty in moisture content increased until at 200° F., the average moisture content of a given specimen at the time of test was known only to within about ±2 percent moisture content.

Log decrement: Errors in log decrement measurements arose from 1) random variation in the measured quantity because of spurious noise in the vibration signal and electronic noise in the amplitude discriminator, and 2) error in calibration. Actually, calibration errors resulted essentially from the spurious noise, as calibration was achieved by measuring the log decrement of vibration of a standard specimen. By replicating the measurement, uncertainty in the indication could be reduced. Generally, about 10 replications were made of a given measurement; of these 10 replications, usually about half of the indications of reciprocal log decrement were within ±1 integer of the average and a total range of ±3 integers was typical. The average of any 10 replications, therefore, probably was influenced by purely random effects no more than ±1 integer. As this uncertainty of ±1 integer appeared in the calibration and also the actual measurement, each measurement was subject to a range of uncertainty of about ±2 integers. The probable error in the average of a group of measurements would, of course, be less than this.

Discussion of Results: The resonant frequency (or speed of sound) and, therefore, the Young's modulus decreased with increasing temperature or with increasing moisture content, as shown in Figures 4, 5, 6, and 7. The decrease in resonant frequency with increasing moisture content was due partly to the higher density and partly to the lower Young's modulus of the more moist wood. Table 2 shows these two effects separately. The observed effect of temperature and moisture content on the speed of sound and Young's modulus is in agreement with generally accepted information on this subject, but no clearly defined maximum was found in the relationship of Young's modulus to moisture content, as was found by Kollmann and Krech (7).

The present data showing the effect of temperature and moisture content on the speed of sound and Young's modulus, however, are apparently distorted by differences between the average basic properties of the different groups of specimens. At least part of this basic difference is specific gravity, but there appear to be other unrecognized influences as well. These influences could easily mask a weakly defined maximum, such as reported by Kollmann and Krech. A more detailed analysis of these data is planned in an attempt to isolate the effect of temperature and moisture content on the elastic properties of wood, and the results of this analysis will be reported later.

The internal friction in Douglas-fir goes through minimum values in its relationship to both temperature and moisture content, as illustrated in Figures 2 and 3. At room temperature, this minimum occurs at about 7 percent moisture content, and the general form of the relationship agrees with the results obtained by Pentoney (4) and Kollmann and Krech (7) at about the same temperature.

An internal friction maximum at low temperatures and moisture content is indicated by the data (Figure 3), but this should be confirmed by additional measurements at lower temperatures.

The moisture content at which the internal friction minimum occurs (Figure 3) decreases as the temperature increases, until at 200° F. there is no apparent minimum above about 1 percent moisture content. Similarly, the temperatures at which minimums occur increase as the moisture content is decreased below about 12 percent. (Figure 2) and for a moisture content near 2 percent, no minimum in internal friction occurs below 200° F. For moisture contents above 12 percent, the minimums all occur at about 40° F.

The variation of log decrement with temperature for the glass-fabric reinforced phenolic bar, plotted in figure 2, shows that the internal friction of the plastic decreases as the temperature increases to 200° F., with no suggestion of an inflection point, much less a minimum. There is a similarity at room temperature and below of the log decrement-temperature relation for the phenolic plastic and the driest wood. This suggests the possibility that the predominant mechanism of internal friction in wood that is completely dry may be the same as that in the non-hygroscopic plastic. Since perfectly dry wood is unattainable, by ordinary means at least, it is plausible that as

the temperature increases, there is a transition in the driest attainable wood to a different mechanism of internal friction that depends on the residual hygroscopic water and increases in magnitude with temperature and moisture content. This could explain the observed divergence of the log decrement-temperature relations of the plastic and driest wood studied here as the temperature increases; specifically, this divergence does not necessarily indicate that the predominate mechanisms of internal friction in the plastic and in perfectly dry wood are different.

It remains plausible, therefore, that the internal friction in wood arises from two basic mechanisms. One of these appears in perfectly dry wood and decreases with temperature much as does the viscosity of most liquids. The other mechanism appears only when hygroscopically bound water is present, and increases with temperature and moisture content.

Interaction between these mechanisms would be expected; for example, below about 80° F. and at about 7 percent moisture content, adding water decreases the total internal friction (Figure 3). It is necessary to assume, therefore, that the hypothetical mechanism of internal friction that predominates in dry wood is decreased in magnitude by adding water. In lower ranges of temperature and moisture content, the decrease in this mechanism is faster than the increase in the mechanism that is enhanced by adsorbed water. Interaction of these two basic hypothetical mechanisms as temperature and moisture content vary could explain qualitatively the observed dependence of internal friction on temperature and moisture content. This simplified description, however, would not readily explain an internal friction maximum at low temperatures.

The true nature of the mechanism or mechanisms of internal friction in wood remain unknown, but because wood is not a good electric conductor, is not ferromagnetic, and is only partly crystalline, mechanisms of internal friction peculiar to these classes of material are probably not important in wood. By elimination, the chief causes of internal friction in wood are likely to be thermoelastic in nature. For example, stress gradients that arise in any strained body because of variations in mechanical properties, or stress gradients that naturally exist in a freely vibrating body give rise to corresponding thermal gradients. These result in generally irreversible heat flow with the consequent degradation of mechanical energy. The basic sources of these stress variations in wood and the processes through which they result in energy degradation need to be explained theoretically.

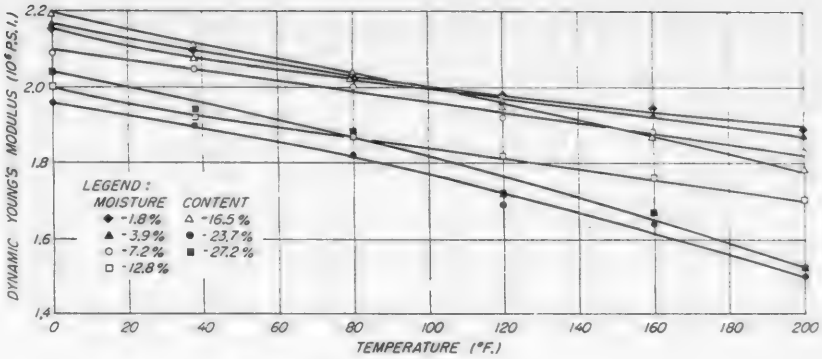

Fig. 7.—Dynamic Young's modulus as a function of temperature at various levels of moisture content.

In considering the internal friction in wood, some interesting relationships can be observed. For example, the internal friction minimum at about 7 percent moisture content at room temperature (Figure 3) coincides with a maximum in some strength properties of wood and paper at about the same conditions (9, 10, 11). Attempts to explain the strength maximum have been based on gross effects, such as the formation of many small internal checks as the fibers dried below 7 percent moisture content or the formation of many regions of local internal stress, both of which reduce the ability of the fibers to withstand external stress. Another possible explanation is that the water monolayer formed during the chemical absorption stage (about 0 to 6 percent moisture at room temperature) may actually improve the bond between cellulose fibers. This would follow if, for example, the bond between the water molecule and the cellulose molecules were stronger than that between two cellulose molecules.

In this case, adding water would increase the strength of the wood or paper up to the limit of chemical adsorption. After the process of physical absorption began to predominate, no additional benefit could be obtained from the "cementing" action of the water and, consequenty, swelling and perhaps saturation of molecular bonds would cause the expected reduction in strength with increasing moisture content.

Any of these suggested explanations for the observed strength maximum could also explain equally well the observed internal friction minimum at about 7 percent moisture content at room temperature by predicting a minimum production of thermal gradients when internal stress and interparticle slipping were minimum. Many details are still missing, such as an explanation of the effect of temperature on the internal friction. A complete theory of the internal friction in wood will require a description of the heat capacity of structural elements of the wood, the characteristic thermoelastic coupling of such elements, the thermal conductivity between these structural elements, and finally the effect of temperature and moisture content on these quantities. Perhaps when more complete experimental data on the effects of temperature, moisture content, and frequency on the internal friction in wood are assembled, it will be possible to develop the needed theory.

Conclusions and Summary

The speed of sound and the Young's modulus of Douglas-fir decrease with increasing temperature and moisture content. Experimental data obtained in this study suggest that the internal friction in wood may result from two basic mechanisms; one that is characteristic of completely dry wood, and one that appears only when hygroscopically bound water is present. The first mechanism is reduced in effect at temperatures between 0° and 200° F. by the addition of water, and the second increases with moisture content and temperature. The relationships between these mechanisms and their relative dependence upon temperature and moisture content result in internal friction minimums in the range of temperature betwen 0° and 200° F. and moisture content from about 2 to 28 percent. At room temperature, an internal friction minimum appears at about 7 percent moisture content. Other data show a strength maximum at about the same moisture content. Both the strength maximum and the internal friction minimum may result from the same basic process.

The internal friction maximum that is indicated at low temperature and moisture content should be confirmed

by additional experiment, because if it is real, it would have a very important effect on the requirements of a successful theory of internal friction.

At this time, no important progress has been made toward developing a theoretical description of internal friction in wood that predicts the effects of temperature, moisture content, and frequency. Because of the unusually complex nature of wood, it is unlikely that such a theory could be developed before fairly complete experimental data are available to guide the thinking of the theorist. It is generally concluded, therefore, that further experimental work is needed; specifically, measurements of internal friction over wide ranges of temperature, moisture content, and frequency.

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forced-air drying of lumber---research and experimental[1]

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THERE HAS BEEN A GREAT UPSURGE of interest in forced-air drying during the past decade. One of the factors that has led to this interest has been the trend toward higher furniture finishes, clear finishes on interior paneling, and similar applications of wood where color and grain show through. Stained lumber marred the appearance of these products, and as a result lumbermen and furniture manufacturers became concerned with how to avoid this problem. Discoloring stains can be eliminated if green lumber can be placed immediately in the dry kiln. This, however, is costly and often impractical.

Stain, warp, checks, and other common defects are almost inevitable in any air seasoning yard where drying is entirely dependent on weather conditions. Some woods, like green hackberry, for instance, will stain severely even in the best of seasoning yards if there are several days of non-drying

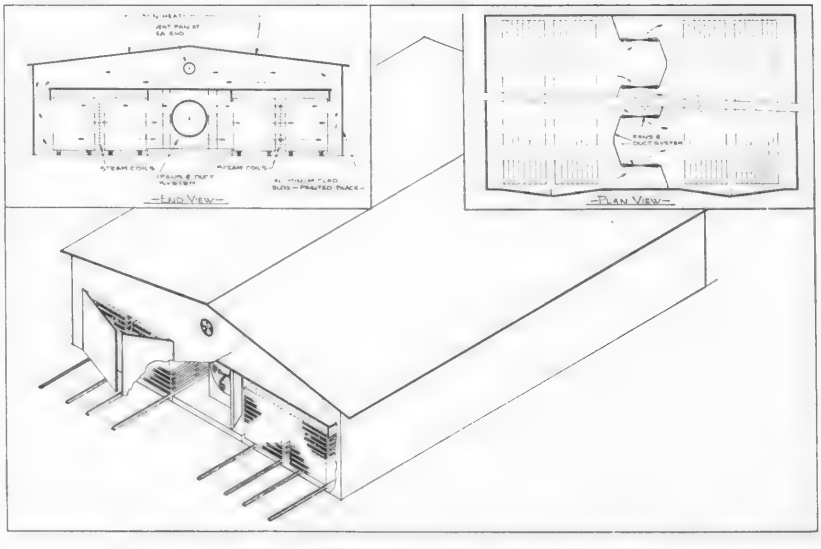

Fig. 1.—Schematic drawing of forced-air dryer.

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 9, Division 8 (Drying A), June 21, 1961.

Forced-air drying is far better than uncontrolled air drying and results in monetary savings from reduced drying time, improved uniformity of drying, and practically eliminates many drying defects. Here, research results are compared with commercial results.

weather with a high temperature and high relative humidity.

Forced-air drying can be a solution to the degrade problem if proper control of air velocities and temperatures is maintained. Only 10° to 20° F. above outside temperature is needed to maintain drying in very wet or very cold weather in contrast to the high temperatures used in conventional dry kilns.

Many types of forced-air dryers have been constructed. They vary from mere lumber stack enclosures with exhaust fans to the modern cross-circulation forced-air dryer with supplemental heat and control instruments.

Research has lagged in this race of progress. Thus, impatient and enterprising lumbermen and furniture men have forged ahead on a trial and error program to produce quick results. There have been some failures, many mediocre successes, and some outstanding results. And of course, research has come plodding along and can now answer some of the questions as to why certain commercial installations work and others do not. The commercial forced-air dryer used in this study was preceded by basic research conducted by the Forest Service in a fully equipped one-load dry kiln at the George Foster Peabody School of Forestry, Athens, Georgia.

We will not answer all questions that might be raised about forced-air drying of different species, but we will provide information that should serve as a guide to anyone building or operating a forced-air dryer.

Commercial Forced-Air Dryer

A forced-air dryer was constructed for one major reason—to eliminate stain and other degrade losses in magnolia. Past practices of purchasing 4/4, 5/4, 6/4, 8/4, 9/4, and 10/4 magnolia that was air dried on local yards resulted in a large amount of stain, both fungal and chemical, that showed up through the natural finishes of the furniture and created severe problems in merchandising.

After considerable consultation with the Forest Products Laboratory, the Southeastern Forest Experiment Station, the Moore Dry Kiln Company, and others, it was decided that much of this stain could be eliminated if the lumber could be purchased green and immediately placed in a forced-air dryer.

It should be pointed out that the company was operating a cross-circulation dry kiln with a capacity of 28,000 feet. This equipment was being taxed because the lumber entering it was of varying thicknesses and varying moisture contents from green to air dry.

The forced-air dryer was designed to meet the needs and production schedule of the company. It was recognized that it must serve as a forced-air dryer and storage area prior to putting lumber in the dry kiln. To meet this requirement, it was necessary to construct a four-track forced-air dryer equipped with fan capacity for a high rate of air circulation, positive ventilation, and a supplemental source of heat (Figure 1). The roof and sides of the metal building were painted black to absorb the sun's energy.

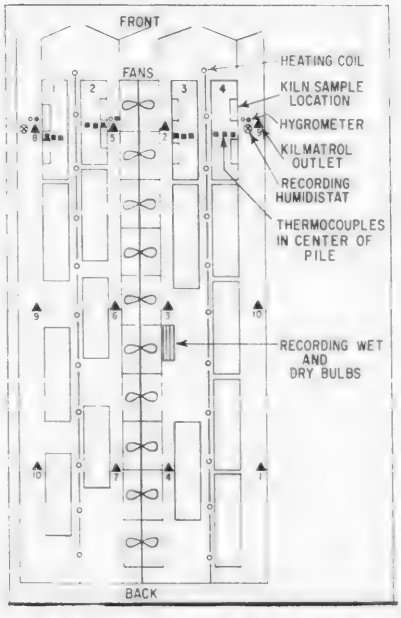

Fig. 2.—Plan view of dryer showing location of thermocouples in test loads at north end.

There are nine 72-inch fans on a line shaft driven by a 30 hp motor. This is directly comparable to the Moore system of circulation in a dry kiln. In addition, there are two motor-driven vent fans, one at each end of the dryer. There are two steam coils (like ordinary booster coils) extending the full length of the dryer between the lumber loads on each side of the fan system.

This forced-air dryer has been operated for more than a year with excellent success. Requirements, however, may differ from those of other plants. Thus its operation bears a little explanation.

Green magnolia lumber is purchased in relatively small quantities by truckload, so one to four kiln trucks are box piled a day and placed in the forced-air dryer. Lumber is purchased only when room is available in the dryer. Since a load of green lumber arrives with several thicknesses up to 10/4, it is not feasible to build separate kiln trucks of each thickness, though this would be desirable. There is never more than one thickness in a course. The capacity of the dryer is 20 to 24 kiln trucks, or about 70,000 feet. At any time, the forced-air dryer will contain all thicknesses and all moisture contents from green on down to air dry.

The forced-air dryer is operated only during the day, with a dry bulb temperature of 100° F. in the summer and 70° to 80° F. in the winter, when outside temperatures are 55° F. or more. Empirically, solar energy will increase the temperature in the dryer about 9° F. on a sunshiny day. A wet bulb controller is set at a 6° F. differential from the dry bulb at which point a small vent fan draws outside air in, causing inside pressure to expel moist air through openings in the

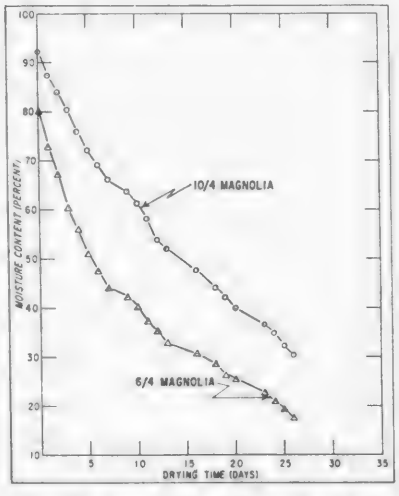

Fig. 3.—Rate of drying of 10/4 and 6/4 magnolia lumber in forced-air dryer at Jacksonville, Florida, January, 1961.

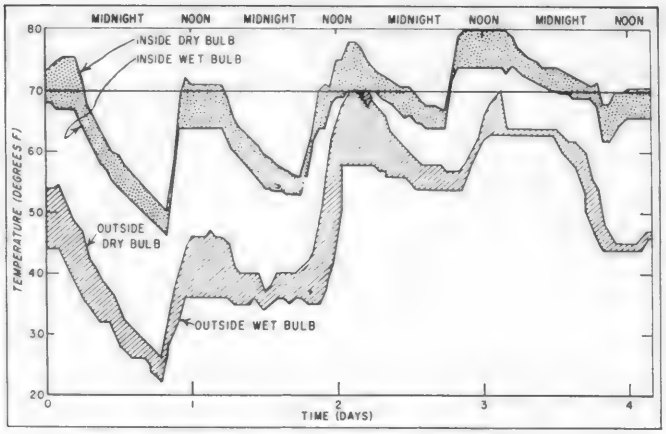

Fig. 4.—Drying potential of air inside and outside commercial forced-air dryer during first 4 days of test at Jacksonville, Florida, January, 1961. The heavy line at 70 degrees indicates a high drying potential above and low potential below.

building. This is set to keep the equilibrium moisture content from exceeding 15 percent. If, however, the wet bulb temperature continues to climb, a second larger vent fan goes on at a 4° F.-difference to maintain a drying condition at 17 percent or below equilibrium moisture content.

At many plants, the operating procedure described might be unacceptable since it results in too great a variation in moisture content of the lumber going into the dry kiln. The capacity of the forced-air dryer at Jacksonville is large enough, however, to act as dryer, equalizer, and storage prior to kiln drying. Since the forced-air dryer has been operating, the demand on the dry kiln has been reduced because lumber was going into the dry kiln at a uniform 15 to 20 percent moisture content. The dry kiln now runs only part-time and keeps ahead of plant requirements.

This means that the forced-air dryer is not crowded, and drying time is not a critical factor. This permits a progressive-type operation and the mixing of thicknesses. It should be emphasized again that the major purpose of forced-air drying at this plant is to eliminate chemical stain; this is accomplished in the first few days that the green lumber is in the dryer.

Since the dryer is operated as a progressive unit, it is difficult to establish rate-of-drying curves or drying capacity. However, by keeping careful records for July, 1960, it was determined that the moisture content was reduced from 70 percent to 20 percent in an average time of 22 days for 4/4 to 10/4 thickness, inclusive. This would indicate a capacity of a little over 1,000,000 feet per year, in the proportions required.

Special Testing in the Forced-Air Dryer

On January 19 and 20, 1961, four kiln trucks of green magnolia lumber were prepared. The first two kiln trucks contained random width and length 8/4, 9/4, and 10/4 lumber. Six sample boards of 10/4 lumber were placed in each load. Kiln trucks 3 and 4 consisted primarily of 6/4 stock, and each load contained six 6/4 sample boards.

The four kiln truck loads were located on the four tracks immediately inside the front of the forced-air dryer. Thermocouples as well as other temperature reading devices were located at various points in the test load. Figure 2 shows the location of test loads and instrumentation.

The drying was started on January 21 with an attempt to maintain a depression of about 6° F. Drying progressed relatively slowly because of extremely low outside temperatures, 26° to 55° F. the first two days and 40° to 60° F. for the next several days.

The temperatures in the lumber lagged 10° to 12° F. below temperatures at the control setting, partly because water was being evaporated from the surface of the wood. Evaporation, being a cooling process, lowers the temperature of the air in and around the green lumber piles. Also, there was insufficient heating capacity to reach the desired temperatures.

Air velocity through the lumber was fairly good, averaging about 400

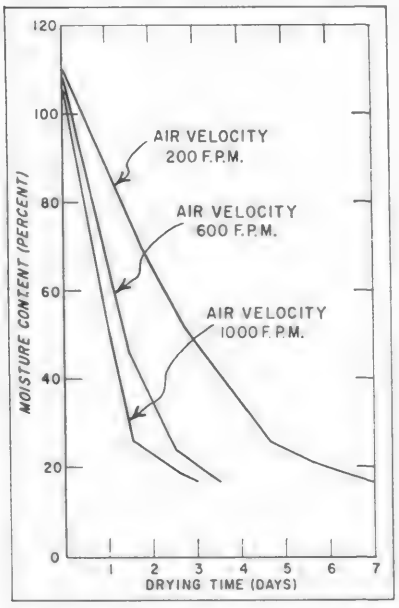

Fig. 5.—4/4 pine lumber dried at three air velocities and constant temperature (80° F.). U. S. Forest Service, Athens, Georgia.

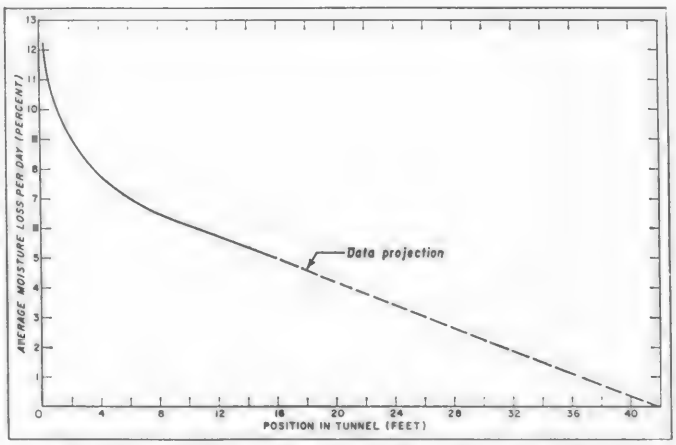

Fig. 6.—Effect of length of air travel on drying rates of 4/4 southern pine. Drying time is 8 days with no control of drying conditions except air velocity (500 feet per minute) and no fan reversal. The average temperature is 75° F.; average relative humidity 85° F.; average equilibrium moisture content 18.3 percent. U. S. Forest Service, Athens, Georgia.

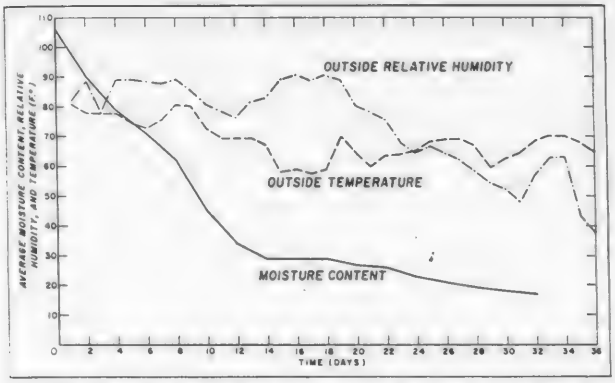

Fig. 7.—Rate of drying of 4/4 lumber in the fall at 200 feet per minute air velocity in the kiln with no temperature control. U. S. Forest Service, Athens, Georgia.

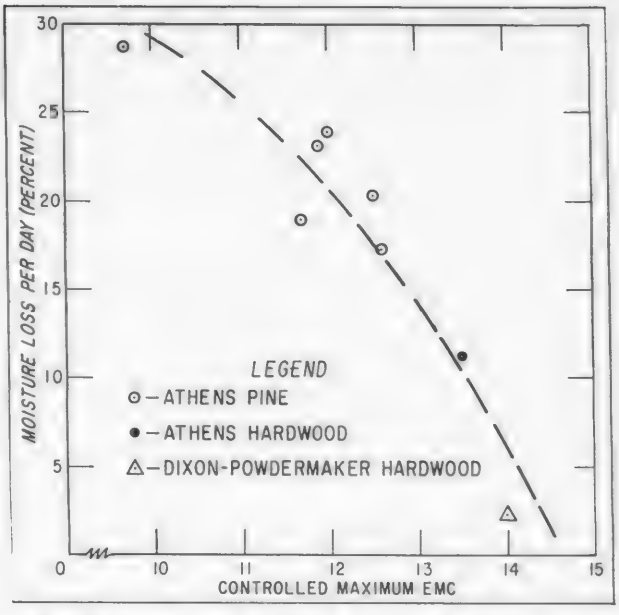

Fig. 8.—Comparison of controlled maximum equilibrium moisture content condition on drying rates in several research tests and one commercial test.

to 500 feet per minute. There were a few locations near the top of the pile, however, where velocities were as low as 70 to 150 feet per minute. These lower air velocities can be attributed to the building of piles too high and thereby baffling the upper courses of lumber. Air velocities of 650 to 800 feet per minute were measured in openings between lumber piles where there was no baffling.

Sample boards were weighed at the beginning and end of each day for the first week. During the remaining part of the run, sample boards were weighed only once at the end of each day.

Adverse weather conditions continued at Jacksonville, Florida, during February and resulted in much slower drying conditions than anticipated. Nevertheless, a constant drying rate was maintained during the operation of the dryer, and the stock did not suffer degrade from stain or other factors.

The drying study was terminated in 26 days, at which time the 6/4 stock dropped from a moisture content of 80 percent to a moisture content of 17 percent; the 10/4 lumber dropped from a moisture content of 94 percent to an average of 30 percent (Figure 3).

A good method to study the effectiveness of a forced-air dryer is to compare the drying potential within the dryer to the drying potential outside the dryer as would prevail under yard-drying conditions. The drying potential can be measured by the difference between the dry bulb and the wet bulb. This potential increases greatly with an increase in temperature. Below 70° F., however, the drying potential is greatly decreased in spite of differences between dry and wet bulb. The conditions that occurred during the first 4 days of test run, and prevailed during the entire run, Figure 4. The shaded areas between dry and wet bulbs indicate the drying potential.

Comparison of Commercial Test with Research Tests

One of the major reasons for making the test run in the commercial forced-air dryer was to check basic research data obtained in Forest Service studies at Athens, Georgia.[2]

More than 30 runs have been conducted in a dry kiln operated as a forced-air dryer at Athens. Most of these runs have been made on 4/4 and 8/4 southern yellow pine, but some runs have been made on poplar, oak, and gum. A few basic principles of drying have been established.

1. The rate of drying increases with increase of air velocity across the lumber (Figure 5). From the economic standpoint, it appears that 500 to 600 feet per minute is best, since added power costs to obtain 1,000 feet per minute do not result in sufficient reduction in drying time.
2. The effect of air travel across the load materially influences drying rate and uniformity of final moisture content. It should be restricted to about 10 feet un-

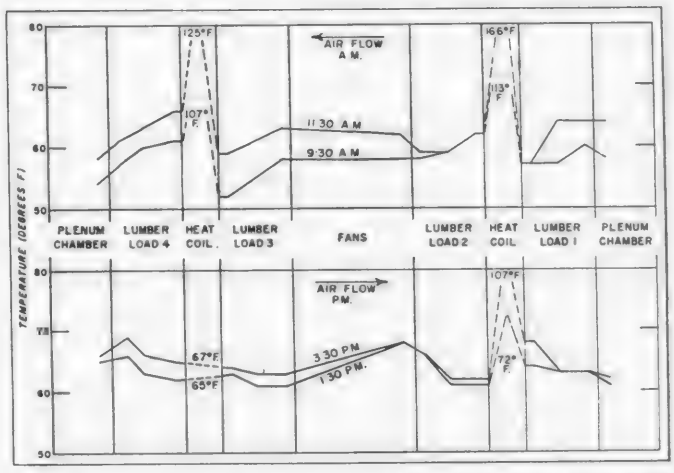

Fig. 9.—Temperature changes across the lumber loads and heating coils in commercial forced-air dryer, Jacksonville, Florida.

[2] Gaby, Louis I. 1961. Forced air drying of southern pine lumber. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 121, 21 pp., illus.

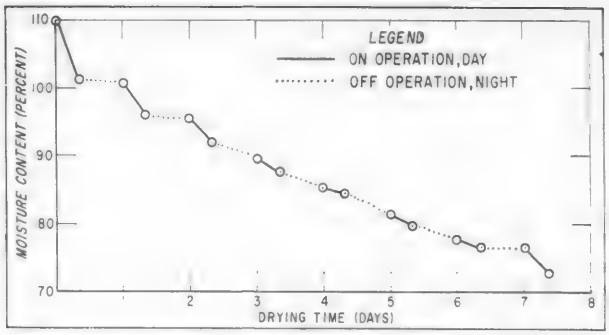

Fig. 10.—Drying rates of magnolia lumber during off and on operation of commercial forced-air dryer during first 7 days of test at Jacksonville, Florida, January, 1961.

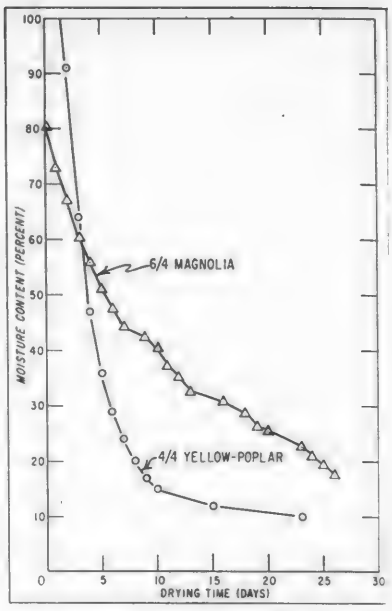

Fig. 11.—Comparison of drying rates of 4/4 yellow-poplar at Athens, Georgia, and 6/4 magnolia at Jacksonville, Florida.

less heat is added between lumber piles (Figure 6).

3. The rate of diffusion of moisture in wood is directly related to temperature, and thus the rate of drying is directly related to temperature. Minimum temperatures of 70° to 80° F. must be maintained to assure rapid drying. This is espcially true at moisture contents below the fiber saturation point (about 30 percent) (Figure 7).
4. The speed of drying is directly related to the capacity of the air to absorb moisture. This can be measured by the relative humidity or more directly by the equilibrium moisture content condition. The lower the equilibrium moisture content, the more rapid the rate of drying (Figure 8).

These principles are verified by the results obtained in the commercial forced-air dryer of the Dixon-Powdermaker Furniture Company. The air velocity in the commercial unit averages around 400 feet per minute and is not a limiting factor in the drying rate.

The temperature drop across the lumber load and the need for added heat is shown in Figure 9. The slight temperature increase across the fans is due to a mixture of warmer air from other parts of the dryer. A longer air travel would retard drying on the leaving-air side of the load, thus causing a longer drying period and lack of uniformity of lumber moisture content.

The effect of temperature on drying rate is dramatically shown by the commercial run at Jacksonville, which was made during extreme conditions for that locality. Figure 4 shows the dry and web bulb temperatures during the first 4 days of drying both in and out of the dryer. Outside temperatures dropped below freezing and were abnormally low during the whole period. The drying that took place occurred when the temperature inside was above 70° F. and the drying potential (shaded area) large. Figure 10 shows that during the first few days in the dryer drying stopped during the night hours when the fans and heat were off. Later in the drying run, some drying apparently took place during the night because of residual heat in the lumber.

Figure 11 shows the drying curve for the 6/4 magnolia at Jacksonville and an experimental charge of 4/4 poplar dried at Athens, Georgia, with a constant dry bulb of 80° F., a constant web bulb of 69° F. giving a constant equilibrium moisture content of 10 percent. The experimental charge was run 24 hours a day, and the commercial charge of 6/4 magnolia was run only about 8 hours per day. The similarity of the curves is obvious, and it is apparent that the magnolia curve would closely approach the poplar curve with full-time operation and a maximum equilibrium moisture content of about 10 percent instead of 14 percent.

Summary and Conclusions

Forced-air drying is a sound method of using the known laws of physics to obtain rapid drying of lumber. Because relatively low temperatures are used, the process can be accomplished in a low-cost building.

Research has shown that air velocities of about 500 to 600 feet per minute are optimum from the standpoint of drying rate balanced against fan operation costs. Without intermittent reversal of fans, air travel across lumber should be limited to 10 feet to maintain fast and uniform drying in all parts of the lumber pile.

Temperature is extremely important in forced-air drying and should be maintained above 70° F. When equilibrium moisture content exceeds 12 to 14 percent in the dryer, additional heat is necessary to maintain the drying rate and to avoid staining of green lumber. This usually requires an inside temperature of 10° F. to 20° F. above outside temperature during humid periods and at night if round-the-clock drying is desired.

The above facts have been established in research studies by the Forest Service and have now been tested and found applicable in a commercial forced-air dryer at Jacksonville, Florida, where operating conditions favor daytime drying only and where various thicknesses of magnolia lumber up to 10/4 are included in the same charge. Drying degrade has been almost eliminated, and drying costs have been reduced.

It is apparent that forced-air drying has an important place in the wood using industry if executed in accordance with established principles.

The Authors: Mr. Rucker is president of the Dixon-Powdermaker Furniture Co., and president of the National Association of Furniture Manufacturers. Mr. Smith is chief of the Division of Forest Utilization Research, Southeastern Forest Experiment Station, and an Executive Board representative for FPRS Southeast Region.

The Inelastic Behavior of Wood: A New Concept for Improved Panel Forming Processes[1]

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Here is fundamental information on the inelastic behavior of wood that can be used to analyze many of the problems associated with the manufacture and use of particle board. Although exploratory in nature, the work has already suggested additional areas for fruitful research that may eventually provide leads to the solution of such problems as telegraphing, springback, and improved dimensional stability until the ideal consolidated panel of low density and high strength can be achieved.

IN CONVERTING WOOD from its green biological condition into a variety of useful products, the various processes employed subject it to inelastic stresses in compression perpendicular to the grain. These stresses may be self-imposed, as in kiln drying, or mechanically imposed, as in machining or in the manufacture of such products as plywood, particle board, and hardboard. The magnitude and effect of these compressive stresses depends upon the elastic properties perpendicular to the grain and inelastic behavior of the wood, and determines the range in use and safety in service of a particular manufactured product.

Little is known about the inelastic behavior of wood in compression perpendicular to the grain. To date, a very limited amount of research on a few species has been conducted to assess this behavior (3, 5, 6, 7, 13, 15, 17).[1] This is indeed surprising when one considers the number of processes, which are dependent in some way upon the inelastic behavior of wood.

In this regard, the particle board process is of particular interest. Almost without exception (15), all the research that has been conducted in the particle board field has been limited to an evaluation of its properties as functions of the variables associated with its manufacture. Briefly enumerated, some of these are 1) moisture content of the particles; 2) pressing temperature; 3) pressure; 4) type, size, and shape of particles; 5) density; 6) type and amount of adhesive used; and 7) formation variables peculiar to a given process used in producing the finished board. It is evident with the vast number of variables present in any given process and the complex interactions between them, that, to analyze the particle board process on the basis of these intermediate characteristics becomes an almost impossible task. Suchsland (15) has shown that the pressures developed in a particle mat under compression are extremely high and are a function of the species stress-strain characteristics in compression perpendicular to the grain. Thus, the basic problem that has been ignored is research on the inelastic behavior of wood in compression perpendicular to the grain.

It is necessary to define clearly the terms "elastic behavior" or "elasticity" and "inelastic behavior" or "inelasticity" as used in this paper. Elasticity is the existence of a one-valued time-independent relation between stresses and strains. In other words, the mechanical behavior of a body subjected to stresses is called elastic if the strains produced in the body are instantaneously recovered when the stresses are removed. Hooke's "law" of linear elasticity is the simplest form of this relation. Inelasticity, on the other hand, is the existence of a two-valued time-dependent relation between stresses and strains and is meant to define behavior beyond the elastic or

AUTHOR KUNESH, winner of the annual Wood Award Contest, was presented first prize by J. F. Koellisch, editor and publisher, Wood & Wood Products.

The Author: R. H. Kunesh received his M. S. in Wood Technology at the University of Michigan in 1960. The paper is a condensation of the master's thesis.

[1] First-place winner, 1961 Wood Award competition. Also presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 4, Division 1 (Anatomy and Fundamental Properties B), June 20, 1961.

[1] Numbers in parentheses refer to Literature Cited at the end of this report.

Fig. 1.—A conditioned specimen sealed in a plastic envelope is shown.

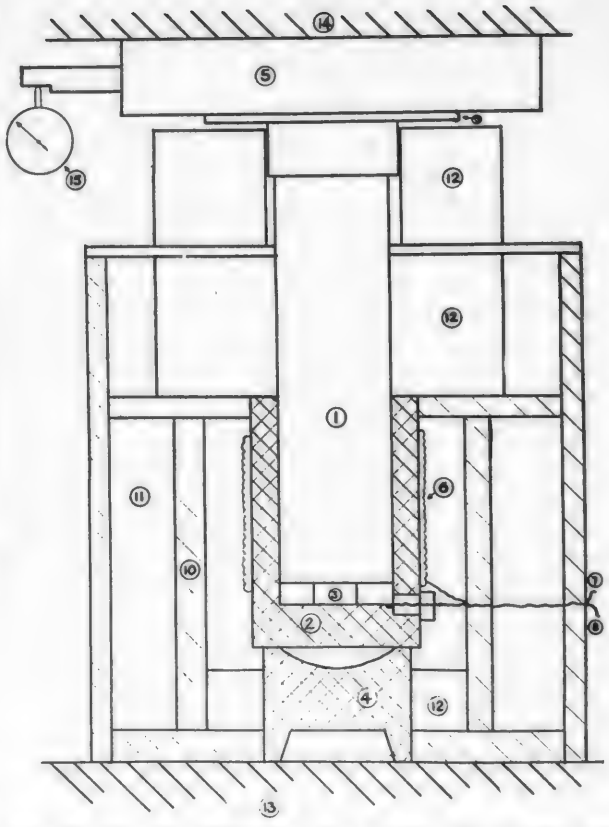

Fig. 2.—Shown is the test chamber: 1) piston, cold-rolled steel; 2) cylinder, cast iron; 3) sealed compression specimen; 4) supporting base, cold-rolled steel; 5) micro-ground mounting block, cast iron; 6) heating tape; 7) heating tape lead; 8) thermocouple lead to potentiometer; 9) transite, sheet compressed cement-asbestos; 10) inner plywood heat box (hatched areas are plywood); 11) insulation, cotton batting; 12) insulation blocks (redwood) attached to removable top; 13) platen of testing machine; 14) crosshead of testing machine; 15) 1/10,000-inch precision Ames gauge. Scale of drawing 1 : 2 inches.

linear range (4). Thus, when compressive stresses beyond the elastic limit are applied to wood, three distinct parts of the associated compressive strain appear as a single entity; the difference between them becomes evident only during and after the removal of the stresses. The recoverable part of the elastic strain takes place instantaneously while the stresses are being removed, followed by a retarded elastic strain (after-effect) after removal of all stresses and an unrecoverable or inelastic strain which is left more or less permanently in the wood.

Inelastic behavior cannot be described in terms of stresses and strains alone since above the proportional limit there is no longer a definite interrelation between them. Thus, inelastic behavior, for the purpose of this study, is described in terms of unrecovered strain, stress relaxation, coefficient of relaxation b, and maximum stress at constant strain, which are defined as:

Unrecovered strain: The inelastic strain remaining in the wood after removal of all stress, expressed in inch/inch, and based on the uncompressed thickness of the test specimen.

Stress relaxation: The amount of stress decay occurring with time when a constant strain is maintained, expressed in pounds per square inch.

Coefficient of relaxation b: The rate of stress decay occurring with time when a constant strain is maintained, expressed as a parameter of the equation $F = F_o (t + 1)^b$ *(17)* where,

F = stress at time t
F_o = initial stress
t = relaxation time in minutes

Maximum stress at constant strain: The stress, in pounds per square inch, attained at a given level of constant strain.

Review of Literature

Research conducted on unrecovered strain is limited to studies by Seborg and Stamm (13), Higgins (5), Higgins and Griffin (6), and MacDonald (10). In general, they found that compression and unrecovered strain increased with increasing pressures, temperature and moisture content. Higgins (5), in his study on the residual deformation (unrecovered strain) of plywood, found that unrecovered strain increased with increasing temperature on oven-dry material. At 7 to 8 percent moisture content a definite minimum occurred at 320°F., which he termed the "yield value." This minimum was observed at other pressures and was tentatively attributed to the plasticizing action of moisture on wood. Other authors have also referred to the plasticizing effect of moisture on wood (12, 16). In all the studies cited thus far, temperature and especially moisture content were shown to exert an appreciable influence on both compression and unrecovered strain of wood. However, no accurate control over moisture content was maintained during prolonged periods of testing at high temperatures. Barkas and associates (1), commenting on Higgins's study, noted that a variable drying rate was superimposed on the effects of temperature and pressure. Although these conditions are common to various manufacturing processes, the ability to interpret the behavior of the material is difficult, if not impossible, unless the moisture content is kept constant. Thus, the effect of moisture content on the inelastic behavior of wood is unknown.

The first investigation made on the stress relaxation of wood was by Kitazawa (8). He developed an empirical

equation for the stress relaxation of wood given by: $F = F_1 (1 - m \log t)$ where,

F = stress at time t minutes
F_1 = stress at time 1 minute
m = "relaxation coefficient".

Later, Youngs (17) explored the effect of temperature and moisture content on stress relaxation in compression perpendicular to the grain. He found that his data could be more satisfactorily represented by the hyperbolic relationship $F = F_0 (t + 1)^b$, mentioned previously in this paper. The parameter b was found to vary with test conditions in a manner similar to that of the relaxation coefficient m.

Inelastic behavior, previously defined as behavior beyond the elastic range, was made with the implication that the elastic range still remains of considerable, if not primary, importance. Thus, the elastic properties as well as the inelastic behavior of wood must be considered. Data on the true strength and elastic properties of wood in compression perpendicular to the grain (2) and the effect of temperature and moisture content on these properties (3, 17) have been limited to a relatively small number of species and conditions. Despite the fact that wood exhibits greater strength properties in the radial than in the tangential direction, few investigators (2, 11) have considered both grain directions in their studies. Ellwood (3) and Youngs (17), using American beech and northern red oak respectively, found that in the tangential direction modulus of elasticity, proportional limit stress and stress at 2.5 percent strain were reduced curvilinearly with increasing moisture content and linearly with increasing temperature.

Purpose and Scope

The purpose of this study was to investigate the effect of temperature, moisture content, direction of test (radial and tangential), and strain level on the inelastic behavior of wood in compression perpendicular to the grain and relate this behavior to the particle board process. Other variables such as specimen size, specific gravity, rate of loading, and duration of load were held to predetermined levels in order to limit or eliminate any influence they might have on the results. These levels were selected on the basis of preliminary experiments, relation to the particle board process, or facilitation of the testing procedure. It was recognized that some of the variables held at predetermined levels could conceivably have an important bearing on the results but to evaluate them, in addition to the selected variables, was beyond the scope of this study. One of the primary considerations of this study was to maintain moisture content at a given constant level before, during, and after testing. Thus, tests were conducted at four levels of controlled temperature and moisture content and at two levels of constant strain above the proportional limit in the radial and tangential directions. The elastic property determined was modulus of elasticity.

Experimental Material and Preparation of Test Specimens

Yellow poplar *(Liriodendron tulipifera L.)* was chosen for the experimental work because it is even grained and compresses more readily than denser hardwoods. Consequently, the effects of temperature, moisture content, and strain level on inelastic behavior should be more pronounced. The material was taken from a single 8/4-inch board, 24 inches wide, and 20 feet long, and free from all visible defects except for occasional pin knots.

Billets, measuring ¾ inch thick by 1½ inches wide by 15 inches along the grain, were cut with the grain alternately oriented in either a true radial or tangential direction. Only those billets were kept whose specific gravity fell within a range of 0.42 to 0.44.[2] This small range was chosen to minimize any influence that specific gravity might have on the results. The moisture content of all billets thus selected was between 6.8 to 7.8 percent. Two groups of 16 billets for each grain direction were randomly chosen and assigned to tests by means of a table of random numbers.

The billets were preconditioned for approximately 2 months in rooms controlled at 80°F. and a relative humidity that would bring them to the desired moisture content. As they approached their respective moisture contents, two billets, one for each grain direction, were transferred to a small dry kiln and conditioned to their assigned temperature and moisture content. Billets for the green condition were stored in water until ready for jointing to final dimensions. After conditioning, the billets were accurately jointed and cut into 10 specimens measuring ½ inch thick by 1 inch wide by 1 inch along the grain. Six specimens were paired, the odd-numbered specimen to be tested at the lower level of strain and the adjacent even-numbered specimen at the higher level of strain. After machining, the specimens were returned and allowed to recondition at their respective temperature and moisture content to compensate for any moisture loss during the machining process. An area described by the spindle of a 1/10,000-

[2] The average specific gravity of yellow poplar is 0.43 based on ovendry weight and ovendry volume. Wood Handbook. 1955. USDA Handbook No. 72.

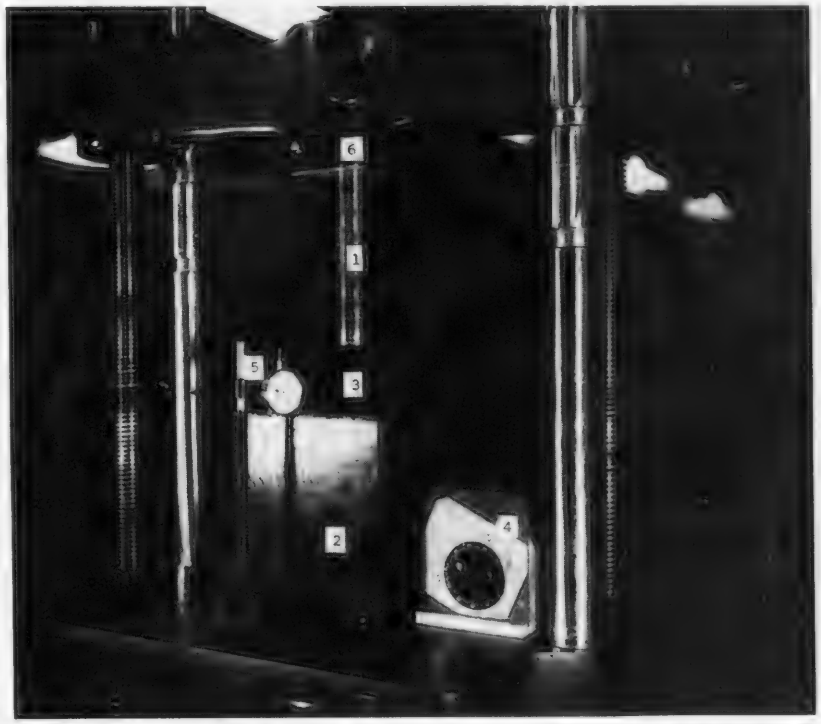

Fig. 3.—A general view of testing equipment is shown: 1) piston; 2) test chamber; 3) removable top of test chamber; 4) variac; 5) 1/10,000-inch precision Ames dial gauge; 6) micro-ground mounting block.

Table 1.—THE INELASTIC BEHAVIOR OF YELLOW POPLAR IN COMPRESSION PERPENDICULAR TO THE GRAIN (RADIAL DIRECTION) UNDER VARIOUS CONDITIONS OF STRAIN, TEMPERATURE, AND MOISTURE CONTENT (AVERAGE OF THREE TESTS)

Strain Level (inch/inch)	Temp. (°F.)	Moisture Content		Unrecovered Strain (inch/inch)	Stress Relaxation (psi)	Coefficient of Relaxation b[1]	Maximum Stress at Strain Level (psi)
		Nominal (Percent)	Actual (Percent)				
0.0240	80	6	7.3	0.0141	270	—0.1042	1197
		12	11.3	.0107	223	.1056	999
		18	21.2	.0041	232	.1893	627
		Green	49.5	.0011	144	.1510	475
	120	6	7.3	.0109	289	.1453	982
		12	12.6	.0090	232	.1986	623
		18	19.0	.0047	214	.2498	476
		Green	61.0	.0013	132	.1905	360
	160	6	7.2	.0078	282	.1697	842
		12	11.8	.0048	230	.1873	636
		18	18.9	.0033	135	.2032	352
		Green	77.2	.0012	64	.1524	208
	200	6	6.3	.0087	208	.1305	776
		12	13.1	.0045	114	.2246	273
		18	18.0	.0019	101	.2044	172
		Green	38.2	.0007	21	.0810	119
0.0360	80	6	7.3	.0221	275	.1033	1252
		12	11.3	.0202	306	.1453	1039
		18	22.2	.0081	254	.2219	616
		Green	49.5	.0019	183	.1929	492
	120	6	7.3	.0200	282	.1306	1052
		12	12.5	.0181	265	.1662	806
		18	19.5	.0074	218	.2364	504
		Green	61.0	.0020	152	.2065	389
	160	6	7.2	.0144	345	.1984	916
		12	11.5	.0132	264	.2187	647
		18	18.1	.0057	160	.2323	388
		Green	77.2	.0017	66	.1513	216
	200	6	5.8	.0159	299	.1820	846
		12	10.5	.0108	214	.2626	458
		18	18.0	.0037	156	.2551	228
		Green	38.2	.0011	37	.1264	140

[1]Parameter of the equation $F = F_0(t+1)^b$.

inch precision micrometer was circled in the center of each specimen for later measuring purposes. One area was chosen in the center to avoid any error due to edge effects. Specimens were then sealed in special heat- and vapor-resistant plastic envelopes (Figure 1) and returned to the rooms where they had been conditioned in billet form to await testing.

Experimental Procedure

Design of the Experiment: Three specimens were tested in compression perpendicular to the grain in the radial and in the tangential directions under each combination of the following conditions.

Temperature: 80°, 120°, 160°, and 200° F.

Moisture Content: Green, 18, 12, and 6 percent.

Strain Level: 0.0240 and 0.0360 inches per inch.

Rate of Strain: 0.013 inches per minute.

Duration of Stress: 10 minutes.

Equipment: The sealed specimens were tested in an insulated piston and cylinder jig mounted on a Baldwin universal testing machine. A schematic cut-away view of the test chamber is shown in Figure 2. A heating tape controlled by means of a variac produced the desired temperatures in the cylinder. Temperature of the cylinder was monitored and measured by a potentiometer connected to thermocouple leads soldered to the inside base of the cylinder. Under these conditions, a temperature control of $\pm 1°$ F. was maintained. Imposed strain was determined by measuring crosshead movement of the testing machine with a 1/10,000-inch reading, ½ inch stroke, Ames dial gauge. A general view of the experimental equipment is shown in Figure 3.

Levels of Strain: Two levels of constant strain, both above the proportional limit, were established prior to testing on the basis of a preliminary experiment. Proportional limit strains were determined by tests on randomly selected samples, one from each previously stated direction, temperature, and moisture content condition. A strain level at 3 standard deviations above the average strain, as determined from these tests, was selected. This strain, 0.0240 inches per inch, was designated as the lower level of strain and another strain, 50 percent greater or 0.0360 inches per inch, was designated as the higher level of strain.

Testing Procedure: Any error in experimentation was distributed by randomizing the order of testing at the various temperature and moisture content conditions. A group of six sealed specimens was taken from the particular humidity room in which they had been stored and placed for 30 minutes in a small experimental dry kiln set at the same temperature and moisture content conditions as those required for testing. This temperature conditioning period was adequate for all parts of the test specimen to reach the desired temperature. Sample specimens with thermocouples inserted at midthickness attained a temperature of 200° F. in 12 minutes.

The piston and cylinder assembly was heated to test temperature prior to placing the specimens in the kiln and the Ames dial gauge calibrated so as to make it a plus and minus reading gauge at that temperature. This was accomplished by placing a ½-inch thick precision gauge block in the cylinder, bringing the piston down in contact with it, and exerting 500 pounds pressure and then presetting the gauge to a reading of 0.0100 inch. Allowance was thereby made for deviations in specimen thickness and any surface irregularities since only the circled area in the center of each specimen was measured and strained to the selected levels. In addition, an exterior reference point was established to indicate when the piston came in contact with the specimen in the cylinder.

After conditioning for the specified time in the kiln, a specimen was removed only long enough to measure its thickness in the circled area to 1/10,000-inch precision with a micrometer and transferred rapidly to the piston and cylinder assembly which previously had been brought to the desired test temperature conditions. The specimen was strained at a constant rate of 0.013 inches per minute until a predetermined strain of 0.0240 or 0.0360 inches per inch was achieved. The crosshead of the testing machine was stopped, the initial stress recorded, and a constant strain maintained for 10 minutes. After 10 minutes, the stress was again recorded,

the load removed and the specimen returned to the kiln. Specimen thickness was remeasured in the center-circled area after one hour under the particular temperature and moisture content conditions in the kiln. It was determined by preliminary experiments that practically all the recovery took place during the first hour after removal of strain under all imposed test conditions.

In addition, for those specimens strained to 0.0240 inches per inch, strain was read at predetermined load increments to give at least 10 readings below the proportional limit. Load-deformation curves were plotted and from these curves values were taken for computation of modulus of elasticity.

After all testing was completed, specimens were removed from their plastic envelopes, weighed, and oven-dried to determine actual moisture content at test.

Results and Discussion

Unrecovered Strain: In general, unrecovered strain decreased with increasing moisture content and temperature (Figure 4) and increased almost proportionately with greater levels of imposed strain up to moisture contents of 18 percent (Tables 1 and 2). Statistical analyses of these data indicated that the strain behavior of yellow poplar in the radial direction was very different from that in the tangential direction. It appears that temperature has no effect on tangential unrecovered strain nor does it combine with the other main effects of moisture content and strain level to affect significantly the strain behavior in this direction. Large differences in the magnitude of unrecovered strain that existed between the two directions below 18 percent moisture content essentially disappeared as the green condition was approached, regardless of the accompanying temperature and strain level conditions. All specimens were examined microscopically and it was found that this difference could be attributed almost entirely to buckling of the rays into adjacent vessels in the radial specimens (Figure 5). The buckled area was confined to the rays in a single growth ring (Figure 6). No visible structural deformations were observed in the tangential specimens at any of the temperature, moisture content, and strain level conditions. No buckling of the rays was observed in radial specimens above temperature and moisture content conditions of 120° F. and 18 percent and 200° F. and 18 percent for the lower and higher levels of strain, respectively. Specimens containing the buckled rays were aspirated in water to the green condition and re-examined. The rays in the swollen condition had completely straightened out making it difficult to tell exactly where the buckling had occured. However, after oven-drying these same specimens the rays re-buckled in the same area indicating they had been inelastically strained in the first instance but that the swelling forces in the wood were of sufficient magnitude to temporarily alleviate this inelastic condition.

Moisture content, more than any other effect, influenced unrecovered strain in both directions. Radial and tangential specimens in the green condition exhibited almost complete recovery of their uncompressed dimensions regardless of imposed conditions of temperature and strain level. Some specimens of both loading directions in the green condition at the higher temperatures fully recovered their uncompressed dimensions even though they had been strained and consequently stressed well beyond their proportional limits. In this regard it is important to note that although all specimens had been strained to the same levels they were subjected to a rather broad range of stresses. These stress differentials are due to not only differences in moduli of elasticity between the radial and tangential directions, but also to a rapid decrease in both moduli with increasing temperature and moisture content (Figures 15 to 18). Ellwood (3) and Youngs (17) also found this same relationship for American beech and northern red oak in the tangential direction. It appears on the basis of these limited data that moisture content has an "elasticizing" and not a "plasticizing" effect so commonly stated in the literature (5, 12, 16). Although wet wood compresses more readily, it is not due to the "plasticizing action" of moisture but to lower stiffness associated with a lower modulus of elasticity. This misleading conception and terminology of the plasticizing action of moisture has been the result of past compression studies which were characterized by control of temperature

Table 2.—THE INELASTIC BEHAVIOR OF YELLOW POPLAR IN COMPRESSION PERPENDICULAR TO THE GRAIN (TANGENTIAL DIRECTION) UNDER VARIOUS CONDITIONS OF STRAIN, TEMPERATURE, AND MOISTURE CONTENT (AVERAGE OF THREE TESTS)

Strain Level (inch/inch)	Temp. (°F.)	Moisture Content (Percent)		Unrecovered Strain (inch/inch)	Stress Relaxation (psi)	Coefficient of Relaxation b [1]	Maximum Stress at Strain Level (psi)
		Nominal	Actual				
0.0240	80	6	7.2	0.0051	136	—0.1049	610
		12	11.1	.0054	101	.1104	478
		18	20.9	.0025	117	.1959	311
		Green	63.6	.0017	87	.1678	262
	120	6	7.5	.0070	147	.1327	538
		12	13.0	.0080	158	.2193	385
		18	18.8	.0052	136	.2506	302
		Green	79.9	.0012	68	.1941	184
	160	6	7.4	.0057	139	.1521	455
		12	11.8	.0058	120	.2000	315
		18	18.3	.0060	79	.2253	192
		Green	66.1	.0009	31	.1562	100
	200	6	6.3	.0065	125	.1600	391
		12	13.7	.0039	49	.2295	116
		18	18.0	.0038	64	.2300	90
		Green	35.8	.0011	15	.1076	66
0.0360	80	6	7.7	.0119	152	.1094	631
		12	11.0	.0110	135	.1209	537
		18	22.7	.0074	126	.2158	311
		Green	63.6	.0026	93	.1741	273
	120	6	7.4	.0120	168	.1551	542
		12	13.0	.0123	139	.1816	393
		18	19.6	.0081	176	.2591	312
		Green	79.9	.0020	71	.1197	197
	160	6	7.1	.0122	158	.1725	465
		12	11.8	.0095	133	.2050	342
		18	17.5	.0065	85	.2176	210
		Green	66.1	.0017	42	.1860	116
	200	6	6.2	.0110	139	.1784	399
		12	10.2	.0114	107	.2282	255
		18	18.0	.0068	97	.2425	134
		Green	35.8	.0010	31	.1256	79

[1] Parameter of the equation $F = F_{\infty}(t+1)^{b}$.

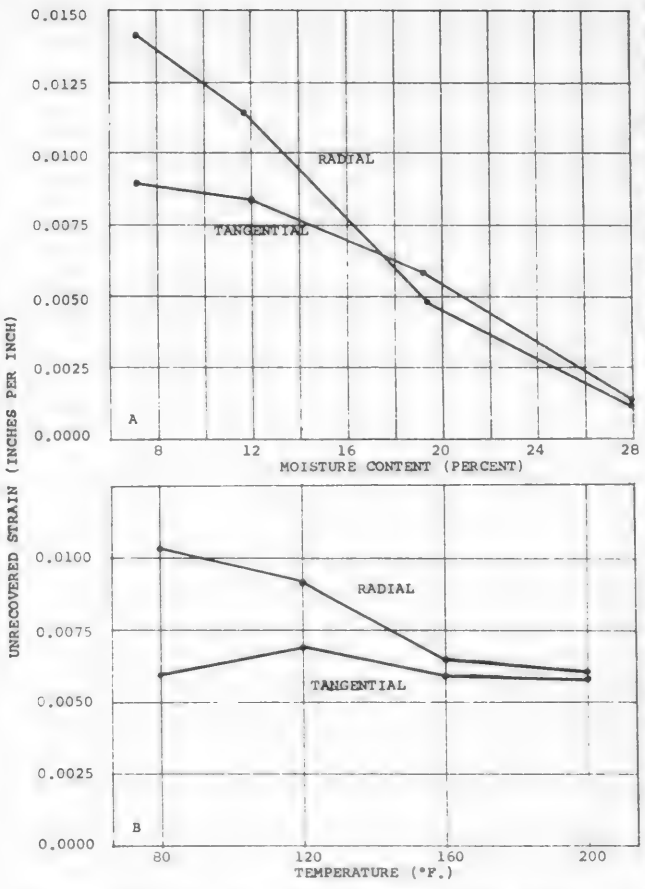

Fig. 4.—Unrecovered strain in the radial and tangential directions as a function of A) moisture content and B) temperature.

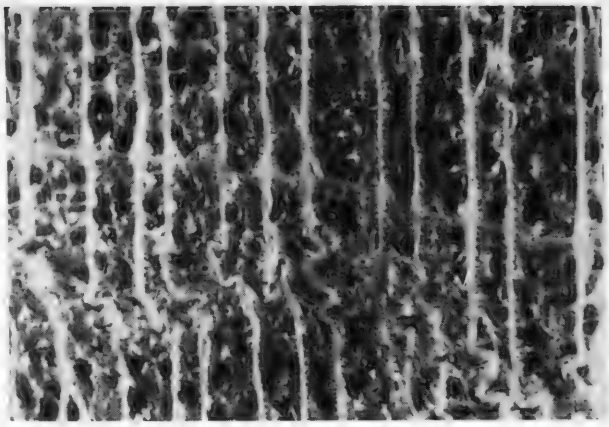

Fig. 5.—Inelastic buckling of rays into adjacent vessels is shown in the radial direction. Test conditions: 80° F., 6 percent moisture content, strain level 0.0360 inches per inch. Magnification 60X.

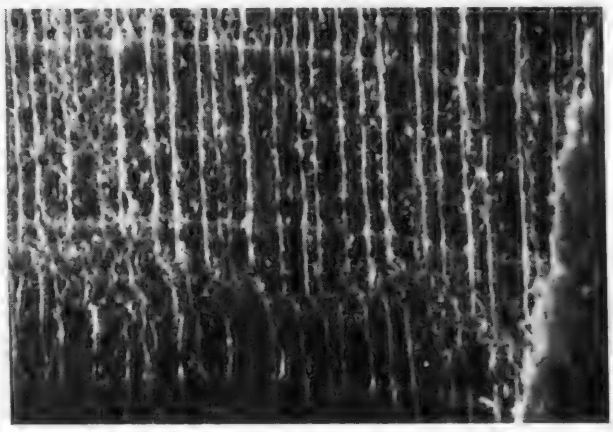

Fig. 6.—Buckling of rays restricted to a single growth ring is shown in the radial direction. Test conditions: 80° F., 6 percent moisture content, strain level 0.0360 inches per inch. Magnification 60X.

and stress but not of moisture content. Thus, in pressing to fixed levels of stress the amount of compression increased with increasing amounts of initial moisture but the accompanying application of high temperatures resulted in moisture losses. The imposed conditions of temperature and pressure were sufficiently high to stabilize or set the compression more or less permanently in the wood. The small recovery of compression associated with these conditions led to the conclusion that it was due to the plasticizing action of the moisture rather than to the recognition of the initial basic change in the elastic properties of the wood which allowed a much greater degree of compression.

Stress Relaxation and Maximum Stress at Strain Level: Statistical analyses of the data for both of these components of inelastic behavior indicated that they were affected very similarly by the experimental variables of temperature, moisture content, strain level, and direction of test. Direction of test affected stress relaxation and maximum stress at strain level more strongly than any of the other variables emphasizing again the significance of the rays in determining both the elastic and inelastic behavior of yellow poplar in the radial direction. However, for each direction, moisture content affected both of these components most significantly because of its influence on the modulus of elasticity. Stress relaxation and maximum stress at strain level both decreased with increasing temperature and moisture content and increased with increasing levels of strain (Figures 7 and 8).

Coefficient of Relaxation *b:* The direction of test had no significant effect on *b* indicating that the structural elements in both directions relaxed at similar rates (Figure 9). Subsequent analyses of variance for the two directions showed that this similarity was due to different effects producing a similar average result. Moisture content, temperature and strain level had strong influences on *b* in the radial direction but only moisture content and temperature affected *b* in the tangential direction (Figure 10). The rate of relaxation generally increased with increasing moisture content and temperature. At first, when *b* was plotted against moisture content, the chevron-shaped curves produced in Figures 9 and 10 were thought to be related to the buckling of the rays. However, a similar behavior of *b* in the tangential direction ruled out ray buckling as a cause since no visible structural deformations were observed in the tangential specimens. The decrease in the rate of relaxation after 18 percent moisture content could possibly be due to a change in some property of the cell walls. Since relaxation is related to the modulus of elasticity and viscosity and because the modulus of elasticity decreases to a relative minimum in the vicinity of 18 percent (Figures 16 and 18) it suggests that this decrease in *b* might be due to a change in the viscosity of the cell walls.

Relationship Between the Components of Inelastic Behavior: The discussion of the inelastic behavior of

yellow poplar has thus far centered on the individual components chosen to describe this behavior, namely, unrecovered strain, stress relaxation, *b*, and maximum stress at strain level. Sample correlation coefficients, statistical measures numerically describing the mutual relationship between measurements, were computed for all combinations of these components in the radial and tangential directions. Very significant correlations in both directions existed between unrecovered strain, stress relaxation and maximum stress at strain level in all combinations, indicating that all three of these components are mutually dependent in determining the inelastic behavior of yellow poplar. Unrecovered strain and stress relaxation appear to be independent of *b*. The rate of relaxation was inversely dependent on the maximum stress at strain level. A highly significant correlation for *b* between the two directions indicated there was essentially no difference in the average rates at which the structural elements relaxed.

Supplemental Tests

A limited series of tests were conducted using higher strain levels to assess further the inelastic behavior of yellow poplar, and in particular, the effects of ray buckling and high moisture content on unrecovered strain. Radial and tangential specimens at 80° F. and conditioned to moisture contents of 6 percent and green were compressed to five levels of strain, 0.0500, 0.1000, 0.2500, 0.4000, and 0.8000 inches per inch, followed by various post-testing treatments. These treatments involved aspirating the 6 percent specimens to the green condition, oven-drying the green specimens and heating other 6 percent specimens at 330° F. for 1 hour and aspirating them to the green condition. After each stage of these various treatments either unrecovered strain or recovery was measured. Testing of the specimens was conducted in exactly the same manner as stated in the procedure of this study. Results of these tests are presented in Tables 3 and 4.

Unrecovered Strain: The magnitude of unrecovered strain for both the radial and tangential directions increased with increasing strain. It was found that the areas and severity of ray buckling increased with increasing levels of constant strain in the radial specimens at 80° F. and 6 percent moisture content. At 0.4000 inches per inch strain, all the rays had buckled throughout the entire specimen followed by a progressive closure of the vessels (Figure 11). At 0.8000 inches per inch strain the specimen was densified to solid wood with all structural identity lost.

Tangential direction specimens began to exhibit some structural deformation at the 0.1000 inches per inch strain level as evidenced by a slight flattening of the vessels and bending of the terminal parenchyma. Structural deformations did not become pronounced until a strain level of 0.4000 inches per inch was reached (Figure 12). It can be observed that vessels are beginning to close and fracture of certain rays has taken place. At 0.8000 inches per inch strain the specimen was densified to solid wood in much the same manner as the previously mentioned radial direction specimen.

Forty-eight hours after pressing these same specimens were aspirated to the green condition. Radial and tangential specimens, with the exception of the 0.8000 inch per inch group, all showed complete recovery of compression upon achieving the green condition (Table 3). Figures 13 and 14 show the radial and tangential 0.8000 inches per inch specimens after

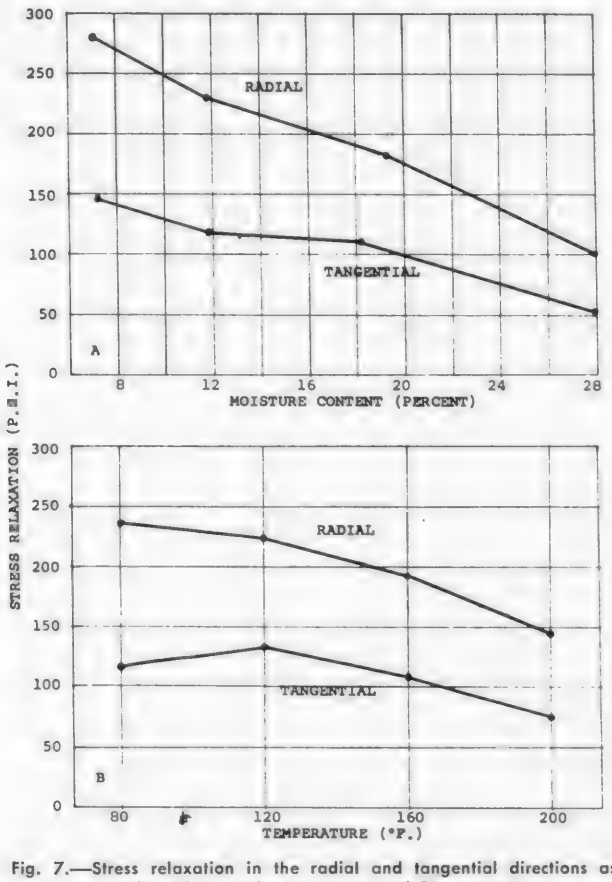

Fig. 7.—Stress relaxation in the radial and tangential directions as a function of A) moisture content and B) temperature.

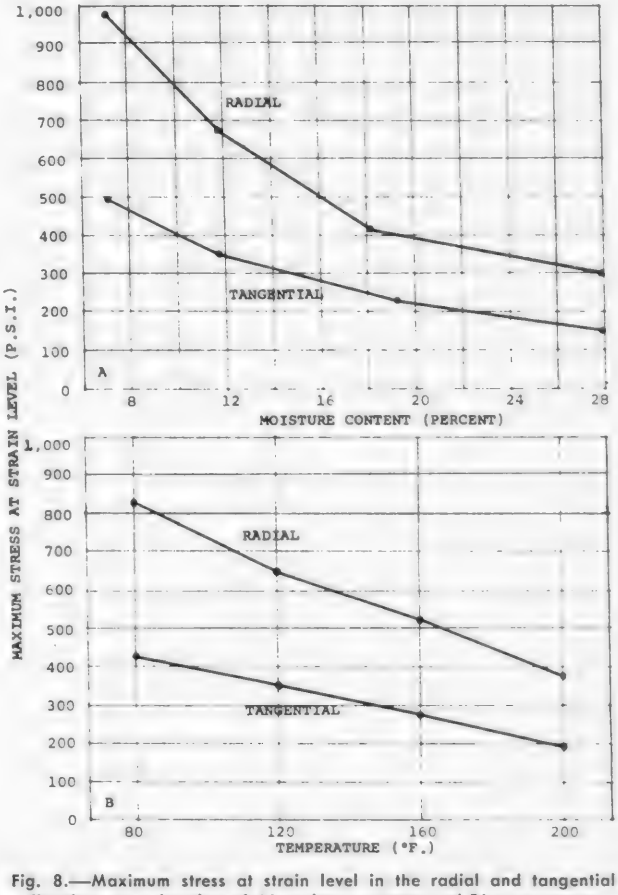

Fig. 8.—Maximum stress at strain level in the radial and tangential directions as a function of A) moisture content and B) temperature.

Table 3.—THE INELASTIC BEHAVIOR OF YELLOW POPLAR IN COMPRESSION PERPENDICULAR TO THE GRAIN AT VARIOUS CONSTANT LEVELS OF STRAIN (SINGLE TEST)

Strain Level (inch/inch)	Unrecovered Strain (inch/inch)	Recovery [1] (Percent)	Stress Relaxation (psi)	b [2]	Max. Stress at Strain Level (psi)	Shrinkage (Percent)
Radial Direction—80°F. and 6% moisture content						
0.0534	0.0311	102.0	695	—0.2657	1475	4.3
.1000	.0537	103.4	435	.1660	1325	6.0
.2520	.1745	102.3	440	.1534	1430	4.5
.3940	.3146	101.6	595	.1567	1900	5.4
.7800	.7334	92.2	-	-	52650	3.4
Radial Direction—80°F. and Green						
0.0518	0.0038	-	215	—0.2283	510	4.8
.1048	.0050	-	188	.1967	500	4.8
.2640	.0190	-	194	.1694	581	4.2
.4170	.0194	-	268	.1895	734	4.9
Tangential Direction—80°F. and 6% moisture content						
0.0540	0.0272	106.8	205	—0.1458	695	9.2
.1018	.0449	106.1	245	.1597	770	8.6
.2524	.1500	104.8	300	.1603	940	8.9
.3822	.2745	105.5	565	.1755	1645	11.3
.7320	.6854	92.0	-	-	40800	6.5
Tangential Direction—80°F. and Green						
0.0540	0.0015	-	91	—0.2031	236	8.2
.1024	.0045	-	81	.1735	238	9.2
.2748	.0117	-	129	.1838	362	9.6
.4160	.0194	-	201	.1941	540	8.5

[1] After aspirating in water for 4 hours.
[2] Parameter of the equation $F = F_o(t+1)^b$.

they had been aspirated. It is interesting to note the amount of structural deformation that still exists in the radial specimens, particularly the rays, while the tangential direction specimens show no effects of having been compressed.

Radial and tangential specimens at 80° F. and in the green condition were strained up to 0.4000 inches per inch. Specimens in both directions exhibited practically complete recovery. The magnitude of unrecovered strain increased with increasing strain but the percentage of unrecovered strain to total strain remained surprisingly uniform after the 0.0500 inches per inch level of strain was exceeded. Radial and tangential specimens were examined microscopically and no evidence of any structural deformations was observed.

Although the tests in this entire study were limited in number and to one species they seem to indicate that wood in the green condition is very highly elastic so long as this condition is maintained. Huhrjanskii (7) presents an interesting theory concerning the deformation of pine under compression. He states that the intermicellar moisture in wood functions as a lubricant affecting its internal-friction

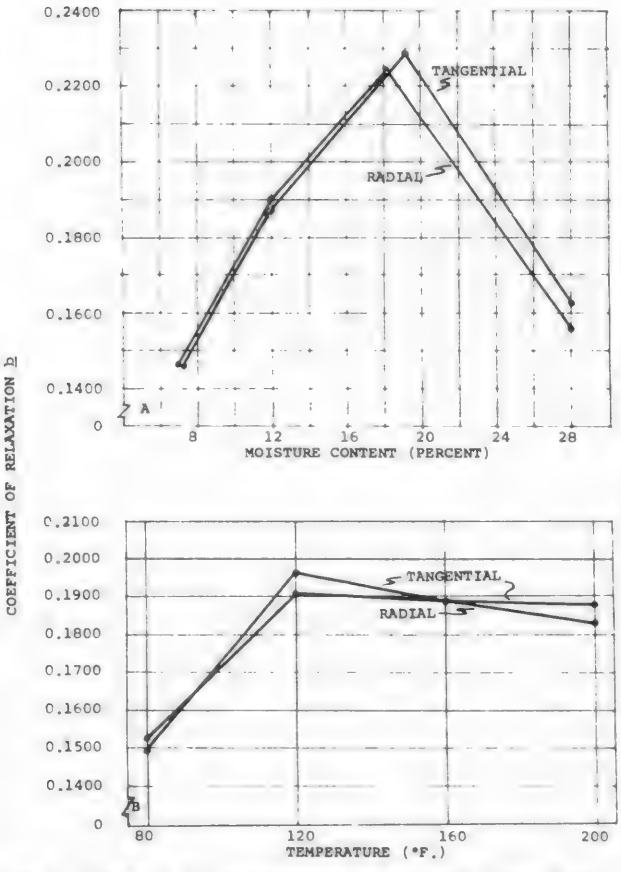

Fig. 9.—Coefficient of relaxation *b* in the radial and tangential directions as a function of A) moisture content and B) temperature.

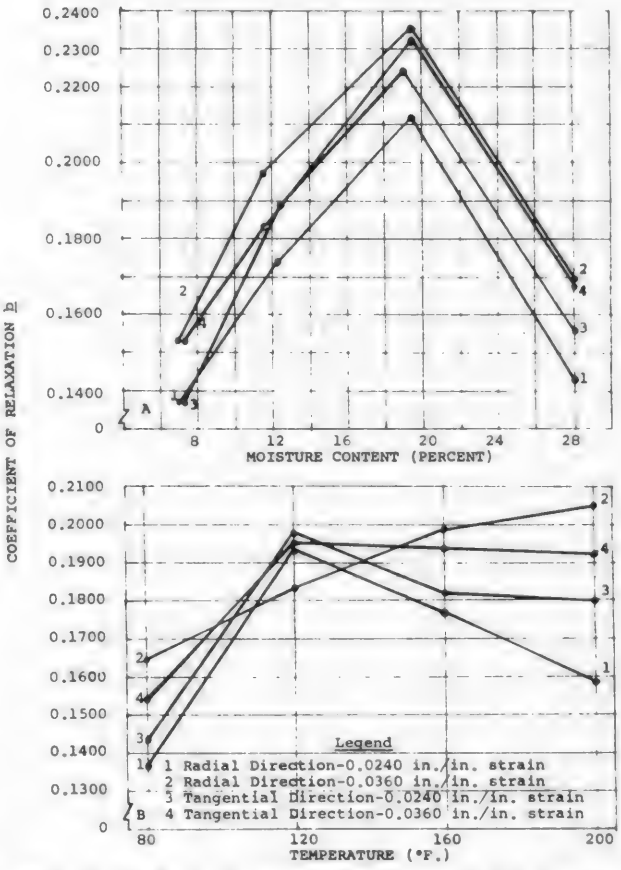

Fig. 10—Coefficient of relaxation *b* in the radial and tangential directions at two levels of strain as a function of A) moisture content and B) temperature.

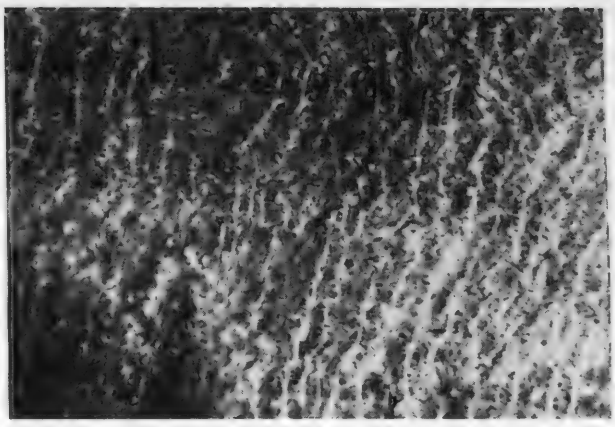

Fig. 11.—Buckling of rays at 0.4000 inches per inch strain shown in the radial direction. Test conditions: 80° F., and 6 percent moisture content. Magnification 60X.

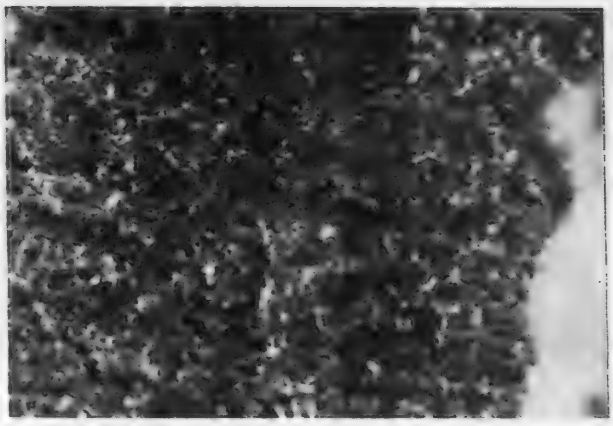

Fig. 12.—Tangential direction specimen at 0.4000 inches per inch strain is shown. Test conditions: 80° F. and 6 percent moisture content. Magnification 60X.

coefficient and this coefficient decreases as the film thickness of intermicellar liquid increases. The values of both elastic and inelastic deformation during compression depend on the amount and viscosity of the intermicellar liquid; as the amount increases the viscosity decreases and elasticity under compression increases and inelasticity decreases. It essentially describes the results obtained in this investigation but the validity of this theory would depend on further research.

The last series of tests in this supplemental phase concerned relieving unrecovered strain by a post-testing treatment of high temperature. Kubler (9) states that strain elimination (loss of unrecovered strain) is favored by high temperatures as well as high swelling rates. Radial and tangential specimens at 80° F. and 6 percent moisture content were strained to two levels, 0.2500 and 0.4000 inches per inch. Unrecovered strain was measured immediately after testing, after drying for 1 hour at 330° F., and after aspirating to the green condition. Results are shown in Table 4. Unrecovered strain decreased after drying and after soaking. The major portion of the recovery took place after soaking. The surprising result of these tests is that recovery of strain took place against shrinkage when the specimens were oven-dried. However, heating at 330° F. did have the effect of setting a greater amount of unrecovered strain in the specimens.

Stress Relaxation, b, and Maximum Stress at Strain Level: In general, stress relaxation and maximum stress at strain level increased with increasing strain at the two levels of moisture content and for both directions. From previous data in this study it was observed that b increased in both directions of test with an increase in strain level and moisture content at a given temperature. This increase generally continued up to the 0.0500 inches per inch strain level, but as strain increased beyond this level b decreased slightly and leveled off, remaining rather uniform up to the limit of 0.4000 inches per inch.

Actual and Computed Unrecovered Strain

Kitazawa (8) found that the relaxation of stress at constant strain below the proportional limit when plotted against time gave a J-shaped curve. Youngs (17) found the same relationship above the proportional limit for northern red oak. In each case the curve was characterized by an initial steep, rather straight portion suggesting the possibility that wood might relax linearly for short periods of time. If this were so, then unrecovered strain could be accurately computed, knowing certain factors in a given loading situation. Rheologists have named such a linearly relaxing body after Maxwell.

In order to evaluate more properly inelastic behavior in materials, idealized models have been devised which behave mechanically like the elements in the real material. A Maxwell model is composed of 1) an elastic spring for elastic deformations; and 2) a dashpot, consisting of a perforated piston moving in a cylinder containing a viscous liquid for viscous deformations. Both of these elements are coupled in series. When loaded with a force the spring undergoes a change in length equal to the force divided by the modulus of elasticity of the spring. At the same moment the piston starts to move and its displacement will increase linearly with time. When the load is removed the spring returns immediately to its original length but the piston retains its acquired position. If such a model can be used for wood then unrecovered strain can be computed from the formula:

$$U_s = U_c - \frac{S_r}{E}$$

where

U_s = unrecovered strain
U_c = constant strain
S_r = stress at end of relaxation period
E = modulus of elasticity.

Table 4.—THE INELASTIC BEHAVIOR OF YELLOW POPLAR IN COMPRESSION PERPENDICULAR TO THE GRAIN AT TWO LEVELS OF CONSTANT STRAIN FOLLOWED BY POST-TESTING TREATMENTS (SINGLE TEST)

Strain Level (inch/inch)	Unrecovered Strain (Inch/inch) After Test [1]	After Drying [2]	After Soaking [3]	Stress Relaxation (psi)	b [4]	Max. Stress at Strain Level (psi)
Radial Direction—80°F. and 6% moisture content						
0.2464	0.2024	0.1457	0.0221	355	—0.1387	1255
.3960	.3263	.2372	.0156	580	.1608	1810
Tangential Direction—80°F. and 6% moisture content						
0.2560	0.1746	0.1242	(103.7%) (recovery)	280	—0.1428	965
.4100	.3144	.2199	.0111	520	.1547	1675

[1] Constant strain level imposed for 10 minutes.
[2] One hour at 330°F.
[3] Aspirating to the green condition.
[4] Parameter of the equation $F = F_o(t+1)^b$.

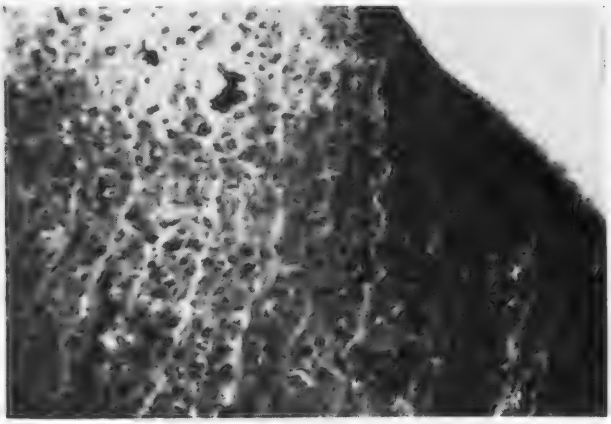

Fig. 13.—Radial direction specimen originally strained to 0.8000 inches per inch is shown, at 80° F. and 6 percent moisture content following aspiration to the green condition. Magnification 60X.

Fig. 14.—Tangential direction specimen originally strained to 0.8000 inches per inch at 80° F. and 6 percent moisture content following aspiration to the green condition. Magnification 60X.

Using this formula, unrecovered strains were computed and compared with the actual test values. There were no consistent correlations between the computed and actual test values for unrecovered strain in either direction at the two levels of strain. It was concluded that unrecovered strain could not be predicted from the formula for a Maxwell body, and that yellow poplar does not relax in a linear manner even for the short relaxation periods of this study. The computed values came closer to the actual values in the tangential than in the radial direction. Some of this variation could be attributed to the buckling of the rays in the radial direction previously mentioned in this paper. The greatest source of variation could be attributed to the modulus of elasticity since accurate determinations of this property are absolutely essential for valid results. Sources of error could also be due to strain measurements determined from machine crosshead movement and determination of proportional limit stress which is largely dependent on individual judgment in analyzing load-deformation data. There was sufficient variation in the moduli to indicate that more than three determinations were needed to establish valid relationships with temperature and moisture content. Curves for the relationships between modulus of elasticity to temperature and moisture content in the radial and tangential directions are given in Figures 15 to 18.

Further research is needed in this area to determine how changes in viscosity with regard to temperature and moisture content affect the inelastic behavior of wood. The means of evaluating this behavior is beyond the scope of this study.

Some Applications of the Results and Further Research

The results of this study provide fundamental information on the inelastic behavior of yellow poplar in compression perpendicular to the grain which can be applied in analyzing the particle board process and some of the problems associated with

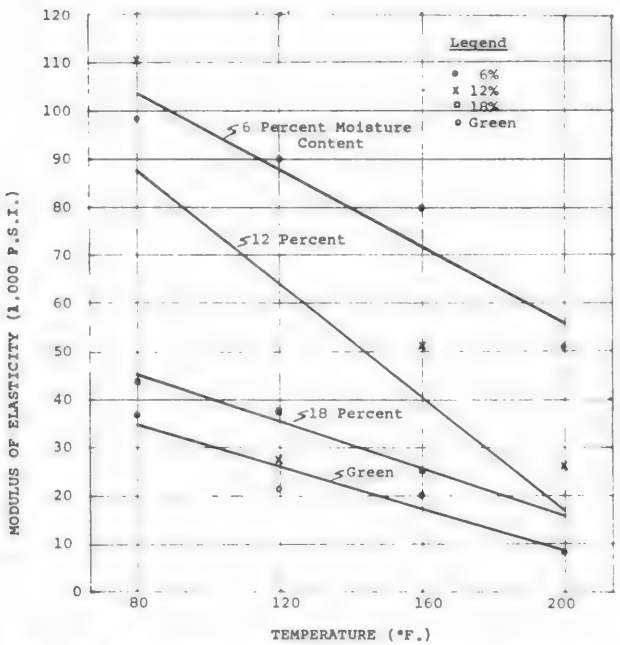

Fig. 15.—Radial modulus of elasticity as a function of temperature.

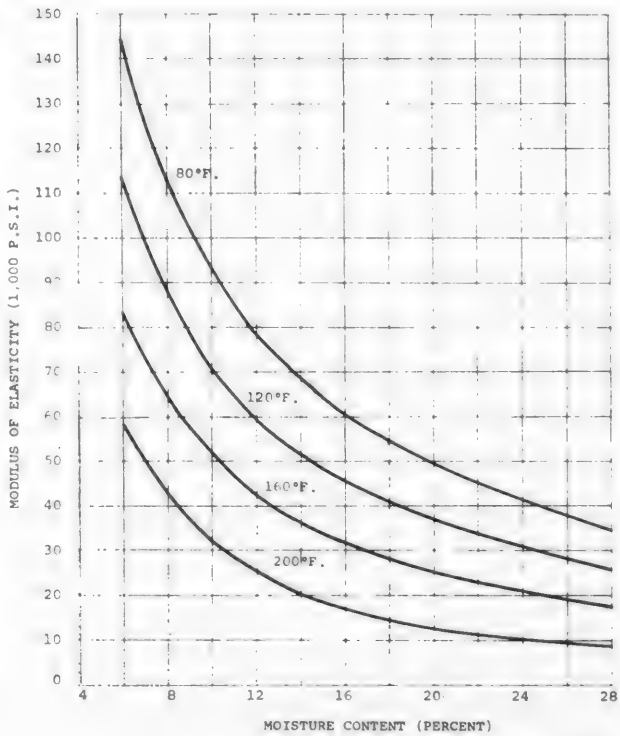

Fig. 16.—Radial modulus of elasticity as a function of moisture content.

its manufacture and usage. Only a few of the more important implications will be mentioned here. In pressing to stops, particles preferably in the vicinity of 18 percent moisture content or higher should be used. High moisture content has several beneficial effects: 1) the wood compresses more readily because of a lower modulus of elasticity, lower stress is exerted, and less power is consumed in pressing; 2) because of lower stress there is much less physical and structural damage of the particles; 3) less unrecovered strain is built into the particle board and hence dimensional stability is improved by minimizing springback tendencies; and 4) there is a faster and more uniform heat penetration through the particle mat which shortens the curing time. Whether high moisture content particiles should be used on the surface or throughout the particle mat depends on limitations of the process, adhesive, and intended end-use of the particle board. Strickler (14) found, within limits of 18 to 21 percent moisture content, that high surface moisture content increased moduli of rupture and elasticity and developed boards that were more dimensionally stable in thickness swell.

Where low moisture content particles are used cyclic exposure at elevated temperature and relative humidity can relieve much of the unrecovered strain originally built into the board.

The amount of compression recovery with increasing temperature and especially moisture content is considerable. Indications are that this recovery, coupled with normal swelling through the thickness, is responsible for the telegraphing and springback phenomena associated with particle board.

The ideal consolidated panel product of low density and high strength awaits the development of an adhesive that will cure under conditions of high moisture and at temperatures around the boiling point of water. This suggests the combination of initially green particles and the use of wet or low pressure steam as a heating medium. If high moisture can be maintained throughout the pressing cycle low pressures will result in a better consolidated product. Upon release of pressure recovery of the highly densified areas should result in producing a product of low density and good strength properties. It could then be dried to the desired moisture content by any conventional means.

While much of this study has been only exploratory in nature it has suggested many areas for fruitful research. The compression characteristics in the radial and tangential directions were shown to be very different. There seem to be advantages in using flakes cut so pressure will be applied in the tangential direction. No research has been conducted to evaluate such orientation and its effect on particle board properties. The inelastic behavior of other species, greater strain levels and higher temperatures should also be investigated. Only when all of these factors have been assessed can effective approaches be taken to improve particle board.

Conclusions

The following conclusions, applicable to the inelastic behavior of yellow poplar in compression perpendicular to the grain, could be drawn from the experimental evidence:

Unrecovered strain, stress relaxation, coefficient of relaxation b, and maximum stress at strain level are significantly affected by moisture content, temperature, strain level and direction of test independently and by various interactions between them. Only the coefficient of relaxation b is not affected by direction of test, indicating that the structural elements in the radial and tangential directions relax at similar average rates.

Unrecovered strain, stress relaxation, and maximum stress at strain level are mutually dependent in determining inelastic behavior. They decrease with increasing temperature and moisture content and increase with increasing levels of constant strain. The relationship between these components of inelastic behavior and the experimental variables serves to demonstrate that it is the elastic properties that are reflected in the inelastic behavior of wood.

The coefficient of relaxation b is independent of unrecovered strain and stress relaxation but is inversely dependent on maximum stress at strain level.

Differences in the inelastic behavior between the radial and tangential directions can be attributed to the rays in the radial direction.

Moisture content, more than any other effect, influences the inelastic

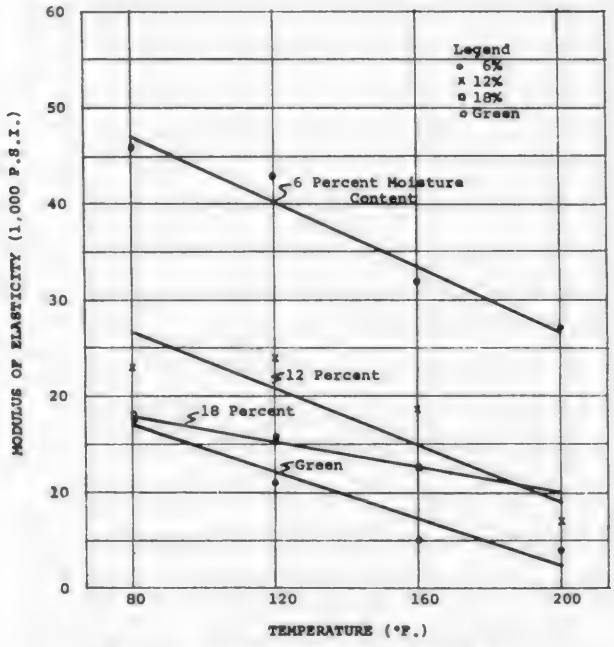

Fig. 17.—Tangential modulus of elasticity as a function of temperature.

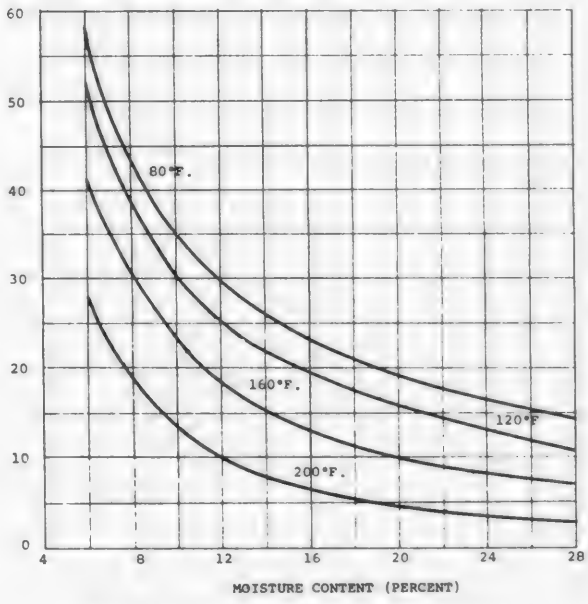

Fig. 18.—Tangential modulus of elasticity as a function of moisture content.

behavior in both the radial and tangential directions.

Elasticity under compression increases with increasing moisture content. Wood in the green condition is very highly elastic so long as this condition is maintained.

Yellow poplar does not relax in a linear manner for short relaxation times.

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Accelerated Test for Measuring Lateral D

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Where complete equilibrium dimensional change under normal conditions may require months, the authors present here a technique which permits a reasonable estimate of the property to be made in less than 4 days. This technique for determining relatively quickly a most important property of board materials should become a practical lab tool.

IN THE OVERALL EVALUATION OF THE physical properties of a panel material, its dimensional response to moisture content oscillations is often ignored because of the tedious method of test. However, lateral dimensional change characteristics of these materials is of major practical importance in both structural and nonstructural applications.

During the course of developing a better understanding of the mechanism governing the lateral stability character of hardboard panels, it became evident that a rapid, reliable, and meaningful method for measuring dimensional change qualities was needed to facilitate research progress. Using conventional procedures, a cyclic exposure of 30 percent relative humidity to 90 percent relative humidity usually requires 20 to 60 days for an untreated ¼-inch hardboard of 1.00 specific gravity. Thicker, denser, or more impervious panels frequently required longer exposure to equilibrate. When these long terms are compounded with a possible malfunction of the humidity control system, the actual equilibration times are measured in months.

Development of Accelerated Test Method

Desirable test criteria are: a) Measurements shall be reproducible within ±3 percent or less. b) Measurements should be made at equilibrium conditions. c) The actual value derived must correlate in a consistent fashion with normal test procedure results. d) The time required for a test measurement should be within days and hours preferably, rather than several weeks which are needed in conventional exposure.

Two experimental approaches were made to speed moisture vapor entry into a panel. These were: a) by pressure differential, and b) by temperature elevation.

A brief series of experiments indicated that introduction of 90 percent relative humidity into an evacuated specimen had an insignificant effect on terminal equilibration time. By contrast, the elevation of temperature increased the rate of diffusion significantly. It became evident that the problem was one of control and accurate correlation with normal temperature and humidity conditions.

For reasons of economy and control simplicity, we elected to use saturated humidity conditions in the 130° to 180° F. temperature range. This range is always above so-called room conditions. (A 90° F. specification is a dif-

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[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 5, Division 5 (Particle and Fiber Processes, A), June 20, 1961.

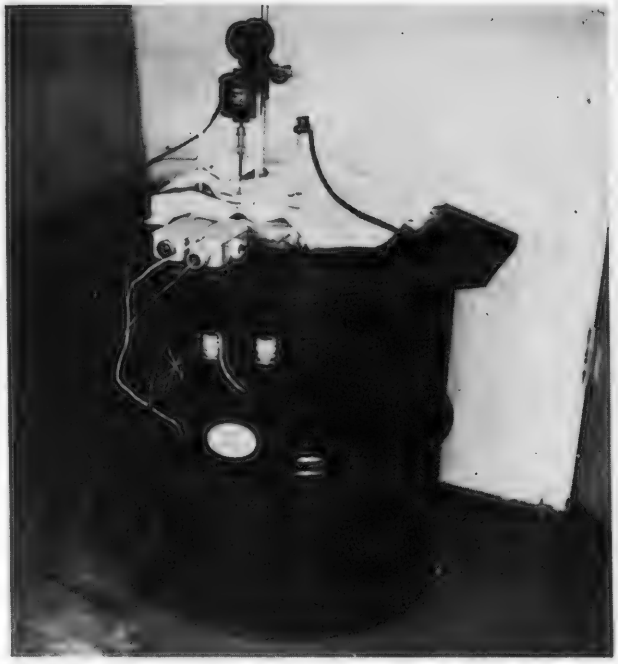

Fig. 1.—Overall view of constant temperature saturated humidity exposure chamber.

Fig. 2.—Inside view of humidification chamber. Specimens are stickered edgewise above expanded metal shelf.

Dimensional Change of Wood-Based Panels[1]

ficult control point in a warm climate, since it must be heated in winter months but alternately cooled and heated in the summer period; this factor compounded and frequently confounded precise humidity control). Although a temperature increase to 180° F. conceivably could introduce chemical reaction side-effects in some materials, this factor was neglected because of the previous temperature exposure and reaction conditions, or both, employed in the panel manufacture.

After a brief series of higher temperature exposures (in saturated water vapor conditions), we found that 150° F., 100 percent relative humidity would yield the approximate equilibrium moisture content of 90° F., 90 percent relative humidity for most of the materials we were studying.

The improvised, but effective, test chamber is shown in Figure 1. Figure 2 shows the test chamber with cover removed and typical rack of test specimens in place. Figure 3 is a cross sec-

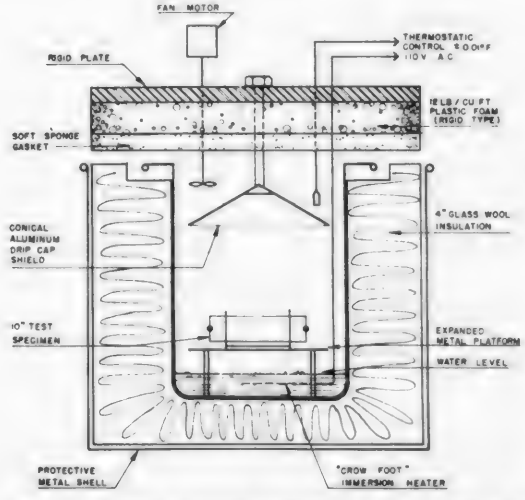

Fig. 3.—Cross-sectional schematic diagram of humidification chamber.

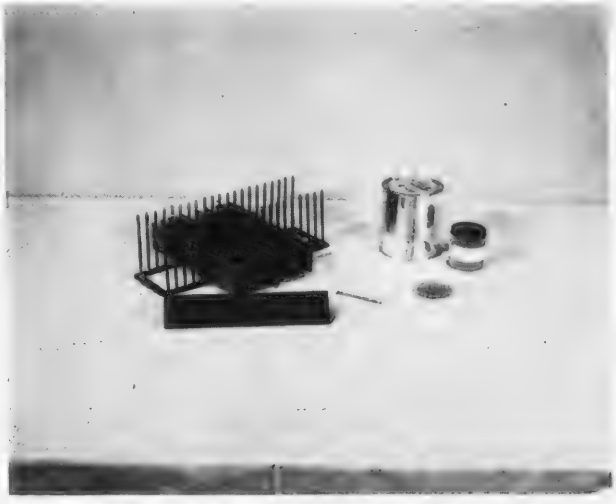

Fig. 4.—Lateral stability test specimens in rack and assembly elements.

Fig. 5.—Measuring apparatus, the length measuring jig is shown with a specimen in place with 0.0001 inch gradation dial at right side, thickness caliper right rear.

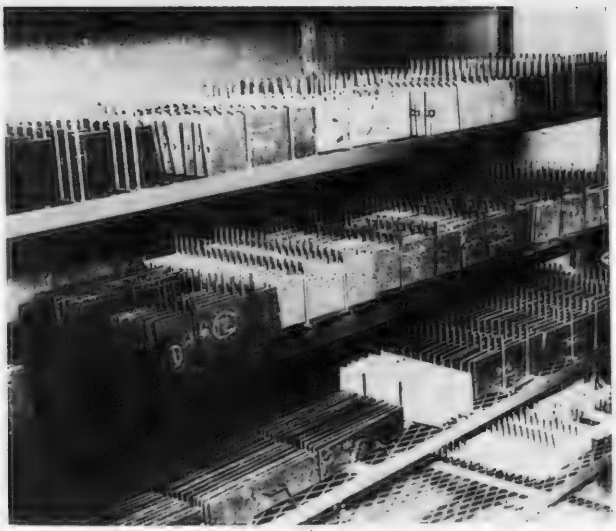

Fig. 6.—Typical rack of test specimens. Racks must be spaced and under forced air movement.

tional schematic sketch of the principle elements involved.

Specimen Preparation and Measuring Technique: An essential auxiliary to this test method is specimen preparation and measuring technique. The procedure we found to be expedient and satisfactory is as follows:

1. Cut the test strips 2-inches by 10⅛ inches. Generally two pieces were cut at 90° orientation so as to detect effect of machine direction on dimensional change.
2. At the center point on each end of the piece, a ⅛-inch hole was drilled near the edge. The entire end was then carefully ground on a belt sander until about one-third of the drilled hole was open.
3. A ⅛-inch diameter stainless steel ball was then pressed into the partial hole and cemented in place with a room temperature setting epoxy adhesive. After a little practice, this procedure yields end-to-end length of 10-inches ±0.020-inch. Thus, for most purposes, direct measured differences can be converted directly to percentage values. Figure 4 illustrates a typical assembly and a stack of test specimens ready for overnight cure.
4. The measuring jig is shown in Figure 5 along with a thickness caliper and balance; readings could be estimated to ±0.0002 inch.
5. An array of specimen types is shown in a typical test rack in Figure 6. Close observation shows that the end balls on thick specimens are not located at mid-thickness; this was not found to interfere with test accuracy. Specimen thickness ranged from 0.100 to 0.750 in this program.

Exposure Cycles: Normal conditions (90° F.) consisted of:

1. Equilibrate to 90 percent relative humidity to relieve initial manufacturing stresses.
2. Transfer to 30 percent relative humidity, 90° F. room, equilibrate, and measure.
3. Transfer to 90 percent relative humidity, 90° F. room, equilibrate, and measure.
4. Oven dry at 230° F. for 3 hours, cool in dessicator, then measure.

The accelerated procedure consisted of:

1. Equilibrate at 30 percent relative humidity.
2. Transfer to 150° F., 100 percent relative humidity, test cell and equilibrate for 72 hours, remove specimen and immediately wrap tightly in a polyethylene bag and allow to cool to 90° F., then remove, one at a time, and measure.
3. Oven dry 230° F. for 3 hours and measure.

Subsequently, we omitted the lengthy 90° F., 30 percent relative humidity equilibration to save time in screening type evaluations. Thus, dimensional change over the 0 percent to 90 percent relative humidity equivalent was generally used for most research testing.

Table 1.—COMPARISON OF NORMAL (90° F.) AND ACCELERATED (150° F.) HYGRO EXPANSION TEST RESULTS

Product Type	Manufacturer	Cycle Exposure			Equilibrium Moisture Content	
		0–30%	30%–90%	0–90%	30%	90%
¼-inch hardboard	(A)					
Normal (N)		0.25%	0.29%	0.54%	4.55	11.8
Accelerated (A)		----	----	0.48	----	13.0
¼-inch hardboard	(B)					
N		0.16	0.30	0.46	3.55	8.87
A				0.49		8.74
¼-inch hardboard	(C)					
N		0.26	0.42	0.68	4.17	10.5
A				0.63		11.2
Particleboard	(D)					
N		0.23	0.53	0.76	5.12	13.5
A				0.75		13.8
Particleboard	(E)					
N		0.20	0.36	0.56	5.27	13.8
A				0.59		14.2

Results

A condensed summary of data is given in the table. Although more extensive data is available, we believe the selection presented establishes the validity of the accelerated method. It especially justifies consideration for research and other purposes where a need exists for rapid, relatively low-cost determination of dimensional change characteristics of wood-based panel products.

Hot- and Cold- Solvent Technique for Creosote Extraction[1]

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IN THE EXAMINATION OF CREOSOTED WOODS, either for quality control or for research purposes, it is necessary to extract the creosote from the wood to obtain such information as retention, distribution, and properties of the creosote. Extraction with hot, refluent toluene is the method that has been used since 1934 to determine the retention and distribution of creosote in wood. This method, developed by Waterman, Koch, and McMahon, (1)[2] employs a Soxhlet-type apparatus in which toluene is refluxed for many hours over small splinters of wood. The method, however, is not entirely satisfactory for two reasons. First, after a period of exposure and weathering, the residual creosote in the wood is not completely soluble in toluene so that not all the creosote is removed. Second, prolonged contact with boiling toluene induces change in the composition of the creosote so that the extract is not completely representative of the preservative in the wood.

Therefore, a method (2) was developed for extracting a sample of creosote that is more representative of the residual creosote in the wood and that provides a measure of the differential solubility in toluene and in pyridine (a measure of the extent of chemical change that has occurred during weathering of the creosote). The new method can also be scaled up in size so that large volumes of wood can be safely extracted and the extract used for extensive tests.

This improved method consists of continuously percolating fresh toluene at room temperature through a vertical column of finely divided shavings of the wood to be extracted. Percolation is continued until the effluent is colorless. The toluene extraction is followed by a similar percolation with pyridine until the effluent is also colorless. The solvents are then stripped from the extracts under partial vacuum and at relatively low temperature, and the resulting samples of extracted creosote are suitable for further analysis.

When a creosoted wood sample is to be extracted, it should be reduced to small pieces to increase the area of contact with the solvent and thereby reduce the time required for complete extraction of the creosote from the wood. This process has conventionally been done by manually splitting the

Fig. 1.—Mechanical mill used to reduce ¾-inch stake samples to shavings suitable for extraction.

Fig. 2.—Apparatus for moisture and creosote determination used in hot-toluene extraction method.

Fig. 3.—Six extraction units used in creosote extraction by the toluene-pyridine method.

A method has been developed for extracting the residual creosote from weathered wood. It consists of shaving the wood by a motor-driven shaving mill, percolating toluene and then pyridine through the shavings at room temperature, and measuring the loss in weight of the wood. It extracts the creosote more completely than the conventional method and provides a measure of differential solubility in toluene and pyridine. It is also readily scaled up in size so that large volumes of wood can be extracted and the extract used for extensive tests useful in research.

sample into match-stick-sized splinters with a knife. To permit greater efficiency of extraction and to speed the splintering operation, a motor-driven shaving mill was developed to produce thin shavings well suited to rapid extraction of the preservatives from the wood.

To establish the reliability of the room-temperature toluene-pyridine method, the Applied Research Laboratory made a statistical evaluation of both this method and the conventional hot-toluene method. The evaluation also included a comparison of the mechanical shaving of wood with the conventional hand splitting.

Materials and Experimental Work

Materials: Southern pine sapwood stakes, each ¾ by ¾ by 30 inches, were used as the medium for creosote impregnation and subsequent extraction. This wood, which is widely used for piles, posts, and lumber, was selected because about 75 percent of all utility poles are of southern pine.

Three different creosote preservatives were used. Two of these, a creosote containing about 16 percent material boiling above 355° C. and a creosote containing about 32 percent material boiling avoe 355° C. were selected to represent the range of distillation properties commonly encountered in commercial wood-preserving practice. Both preservatives conformed to the specifications of the American Wood-Preservers' Association for coal-tar creosote. Wood treated with these preservatives and weathered for 6 years was used for this portion of the study, because aged and weathered wood is known to present special problems of extraction not encountered in the extraction of freshly treated wood. A third preservative, a solution made up of 70 percent creosote and 30 percent coal tar (containing 40.4 percent residue), was included in this study because of the current interest of the American Wood-Preservers' Association in the development of an extraction method for use in determining the retention of a solution of creosote and coal tar in freshly treated marine piling. The specimens used for extraction in this portion of the study were, therefore, freshly treated with the preservative solution.

Wood specimens were impregnated with each preservative at nominal retention levels of 5 and 16 pounds of preservative per cubic foot of wood to determine whether the concentration of preservative in the wood has any influence on the efficiency of the different extraction methods.

Sampling: To obtain essentially identical samples for extraction by different methods, each stake was divided into two equal samples. To further evaluate the effect that the preparation of the wood might have on the effectiveness of the extraction, each sample was further divided into two

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 2, Division 7 (Treatments and Coatings), June 19, 1961.
[2] Numbers in parentheses refer to Literature Cited at the end of this report.

Table 1.—RESULTS OF EXTRACTION TESTS DETERMINED BY THE WEIGHT-DIFFERENCE CALCULATION

Extraction Method[1]	Preparation	Retention, lb/cu. ft.	Preservative Extracted, pound per cubic foot: Replicate I — 16% Residue Creosote	Replicate I — 32% Residue Creosote	Replicate I — 70/30 Creosote-Coal Tar[2]	Replicate II — 16% Residue Creosote	Replicate II — 32% Residue Creosote	Replicate II — 70/30 Creosote-Coal Tar[2]
Hot Solvent	Shaved	5	4.11	4.36	4.74	3.81	4.02	5.24
		16	12.33	11.62	18.73	12.09	11.54	18.64
	Split	5	3.90	3.75	4.81	3.96	3.71	4.51
		16	11.79	10.94	16.67	11.44	11.06	15.93
Cold Solvent	Shaved	5	4.43	4.96	5.92	4.78	4.87	5.55
		16	12.44	11.17	17.91	12.74	11.72	19.18
	Split	5	3.71	3.66	4.89	3.91	4.36	5.71
		16	11.17	11.37	16.87	11.57	11.19	18.31

	Correction Constant: Resin Extracted from Untreated Samples, pound per cubic foot — Hot-Solvent Extraction: Shaved-Wood Samples	Hot-Solvent Extraction: Split-Wood Samples	Cold-Solvent Extraction: Shaved-Wood Samples	Cold-Solvent Extraction: Split-Wood Samples
Replicate I	0.65	0.76	0.79	0.35
	0.64	0.44	0.81	0.24
	0.78	0.57	0.82	0.17
Replicate II	0.76	0.51	0.75	0.37
	0.66	0.53	1.06[3]	0.60[3]
	0.69	0.58	0.94	0.15
Mean	0.70	0.44	0.82	0.26

[1] Hot solvent = hot-toluene method. Cold solvent = room-temperature toluene-pyridine method.
[2] Actual retentions were 6.4 and 18.8 lb. per cu. ft.
[3] Values not used in calculating averages.

Table 2.—RESULTS OF EXTRACTION TESTS DETERMINED BY THE WEIGHT-OF-EXTRACT CALCULATION

Extraction Method[1]	Preparation	Retention, lb/cu. ft.	Preservative Extracted, pound per cubic foot: Replicate I — 16% Residue Creosote	Replicate I — 32% Residue Creosote	Replicate I — 70/30 Creosote-Coal Tar*	Replicate II — 16% Residue Creosote	Replicate II — 32% Residue Creosote	Replicate II — 70/30 Creosote-Coal Tar[2]
Hot Solvent	Shaved	5	3.86	4.11	4.36	3.86	3.85	4.56
		16	10.16	10.17	14.88	10.55	10.43	17.10
	Split	5	3.54	3.51	4.17	3.88	4.22	4.47
		16	10.45	9.85	13.17	10.31	9.73	12.93
Cold Solvent	Shaved	5	3.72	4.48	5.75	4.30	4.79	5.59
		16	11.60	10.01	16.95	11.68	11.29	17.91
	Split	5	4.03	4.56	4.77	4.09	4.39	5.58
		16	10.72	11.38	15.16	11.58	11.21	16.55

	Correction Constant — Resin Extracted from Untreated Samples, pound per cubic foot: Hot-Solvent Extraction — Shaved-Wood Samples	Hot-Solvent Extraction — Split-Wood Samples	Cold-Solvent Extraction — Shaved-Wood Samples	Cold-Solvent Extraction — Split-Wood Samples
Replicate I	0.85	0.76	1.43[3]	1.07[3]
	0.57	0.44	0.82	0.69
	0.86	0.57	0.88	0.75
Replicate II	0.73	0.51	0.89	0.65
	0.67	0.53	0.88	0.77
	0.63	0.58	1.04[3]	0.68
Mean	0.72	0.57	0.87	0.71

[1]Hot solvent = hot-toluene method. Cold solvent = room-temperature toluene-pyridine method.
[2]Actual retentions were 6.4 and 18.8 lb. per cu. ft.
[3]Values not used in calculating averages.

equal subsamples, one of which was shaved into small flakes or chips and the other split into match-stick-sized splinters.

In the preparation of samples, 4 inches were cut from the ends of each stake to eliminate most of the effect of concentration of preservative at the ends. The 4-inch cuts were discarded. The remaining 22 inches of each stake were then cut into 1-inch sections, and these sections were numbered consecutively. The odd-numbered sections were shaved in the mechanical mill shown in Figure 1, and the even-numbered sections were split by hand with a knife. Two composite subsamples were prepared from each stake by combining the shavings from all odd-numbered sections and by combining the chips from all even-numbered sections. Each composite subsample was thoroughly mixed to ensure the greatest possible homogeneity and was then placed in an air-tight can until needed for extraction. Half of each composite sample was extracted by the room-temperature method and the other half by the hot-toluene method.

Extraction Methods: The hot-toluene extraction method used in this work was essentially the same as the method described by Waterman, Koch, and McMahon (1). This method has been used for many years by such well-known research organizations as the United States Forest Products Laboratory and the Bell Telephone Laboratories, Inc. (3, 4) for determination of retention of creosote and moisture of treated wood. The apparatus used in this method is shown in Figure 2. Minor deviations from the original method facilitated the work without influencing the results of the extraction. These modifications considered of a) the use of a Wiley siphon with a fritted-glass false bottom in place of a wire-mesh basket, and b) the use of a vacuum oven to dry the extracted wood at reduced pressure (29.5 inches of mercury) and at a temperature of 115 ± 5° C. for 8 hours in place of oven drying at atmospheric pressure and at 105 ± 2° C. for 24 hours.

Toluene-pyridine extractions at room temperature were accomplished by first packing the finely divided wood into vertical glass columns, as shown in Figure 3. These columns each had a length-to-diameter ratio of about 10 to 1. Toluene at room temperature was then percolated through the column until the effluent was nearly colorless. The remaining toluene was drained from the column, and pyridine at room temperature was next percolated through the wood until the effluent was also nearly colorless. The dark-colored effluent from creosoted wood samples is shown in the first two columns in Figure 3 and the clear effluent from untreated wood samples in the four remaining columns. (Shaved-wood samples are illustrated in the first four columns, and split-wood samples in the two right-hand columns.)

The room-temperature method employs a sample size of 15 to 25 cubic centimeters of wood. However, the apparatus has been successfully scaled up to use a sample as large as 4,000 cubic centimeters (2). Creosote from large sections of utility poles can thus be recovered for further laboratory analysis.

Determination of Retention: For both the hot-toluene and room-temperature extractions, the amount of creosote retained in the wood was determined by the "weight-difference" method as well as by the "weight-of-extract" method (Tables 1 and 2). Both calculation methods were used in the present work so that differences in retention values resulting from the manner of calculation could be detected.

In the weight-of-extract calculation, conventionally used in hot-toluene extraction, the retention was determined by subtracting the weight of water recovered and the weight of the oven-dry wood after extraction from the initial weight of the sample. From this value, the weight of soluble resins was deducted to give the net retention.

In the weight-of-extract calculation, the weight of recovered extract was obtained by direct measurement. In this method, the very dilute solvent solutions of extract were concentrated

Table 3.—VARIABLES STUDIED AND THEIR LEVELS

Variable	Level 1	Level 2	Level 3
Method	Hot-solvent extraction	Cold-solvent extraction	
Preservative[1]	16 R	32 R	70/30
Retention, lb/cu. ft.	5	16	
Preparation	Shaved	Split	

[1]16 R = 16 percent residue creosote.
32 R = 32 percent residue creosote.
70/30 = a mixture of 70 percent creosote and 30 percent coal tar, the mixture containing 40.4 percent residue.

by distillation, which stripped most of the solvent from the solution and reduced the volume from about 200 milliliters to 15 or 20 milliliters. The concentrate was then transferred to a 30-milliliter semi-microdistillation flask, and the remaining solvent was stripped by the method of Gillander and associates (5). In the room-temperature extractions, the pyridine and toluene extracts were stripped of solvent separately. For this work, however, the weight of extracts shown was the weight of the combined solubility-fractions (toluene-soluble extract plus pyridine-soluble extract). In the weight-of-extract calculation, the extract was corrected for soluble resins and for water, just as in the weight-difference method.

The values used to correct for soluble resins, given in Tables 1 and 2, were obtained by extracting a series of untreated wood specimens. Such a correction is necessary because southern pine sapwood normally contains 1 to 3 percent extractable resins that are removed along with the creosote content.

The water contents of the respective samples used in calculating the net retention of creosote in hot-toluene extractions are reported in Appendix A. These values were determined volumetrically during hot-toluene extraction (6). In calculating the net rentention of creosote in room-temperature extractions, the mean value for the water content of each sample shown in Appendix A was used.

Analysis of Data: The data shown in Tables 1 and 2 were subjected to an analysis of variance with the objectives of a) determining whether significant differences exist in the amount of preservative extracted by the two methods of extraction; and b) determining whether differences that might occur between methods were consistent for the amount of preservative extracted, the retention level of preservative in the wood, and the form and size of wood particles extracted.

The variables and the levels at which they were studied are shown in Table 3. Table 4 shows the sequence in which the work was performed to properly distribute experimental error throughout all extractions.

Results and Discussion

Weight-Difference Method: *Effect of Extraction Method:* The room-temperature toluene and pyridine method is slightly more effective in extracting preservative from both shaved- and split-wood samples than is the hot-toluene method. A comparison of the two extraction methods applied to mechanically shaved wood samples is shown in Table 5. The individual differences vary somewhat about a mean difference of about 0.4 pound per cubic foot. This mean was calculated without the two negative differences because they were the only gross deviations from the trend. When the differences were plotted on probability paper, Appendix B, all but the two negative values fell on a straight line, an indication that something other than random error occurred. This mean difference is consistent with the mean difference between extraction methods of 0.5 pound per cubic foot when hand-split samples were extracted (Table 6).

Effect of Preservative: The kind of preservative was observed to affect the amount of extract that could be recovered. In Table 6, the data on those samples prepared for extraction by splitting show that the difference between the amount of preservative extracted by room-temperature toluene and pyridine and that extracted by hot toluene increases as the amount of residue in the preservative increases. When the wood was shaved, however, no such progressive change in the difference was observed.

Effect of Rentention Level: At the higher retention level there was difficulty in extracting the preservative from split wood. In Table 7, this is reflected in larger differences betwen the amounts of preservative extracted from shaved and split samples at the

Table 4.—TREATMENT ORDER

	Replicate I						Replicate II					
	Hot-Solvent Extraction			Cold-Solvent Extraction			Hot-Solvent Extraction			Cold-Solvent Extraction		
Run No.	Preservative[1]	Retention[2]	Preparation	Preservative	Retention	Preparation	Preservative	Retention	Preparation	Preservative	Retention	Preparation
1	None	--	Shaved	None	--	Split	32 R	16	Split	70/30	5	Split
2	16 R	5	Shaved	70/30	5	Shaved	None	--	Shaved	None	--	Split
3	32 R	5	Shaved	None	--	Shaved	70/30	16	Split	32 R	16	Shaved
4	None	--	Split	32 R	5	Shaved	70/30	5	Shaved	None	--	Shaved
5	16 R	16	Shaved	16 R	16	Shaved	16 R	5	Split	16 R	16	Split
6	32 R	16	Split	32 R	5	Split	None	--	Split	16 R	5	Split
7	70/30	16	Shaved	None	--	Shaved	70/30	5	Split	None	--	Split
8	None	--	Split	70/30	16	Shaved	None	--	Shaved	32 R	5	Split
9	32 R	16	Shaved	16 R	5	Split	16 R	16	Split	70/30	16	Split
10	70/30	5	Split	None	--	Split	32 R	16	Shaved	None	--	Shaved
11	None	--	Shaved	70/30	16	Split	None	--	Split	16 R	16	Shaved
12	32 R	5	Split	32 R	16	Shaved	32 R	5	Shaved	70/30	16	Shaved
13	None	--	Split	None	--	Shaved	70/30	16	Shaved	16 R	5	Shaved
14	16 R	5	Split	16 R	5	Shaved	None	--	Shaved	32 R	5	Shaved
15	None	--	Shaved	16 R	16	Split	16 R	16	Shaved	32 R	16	Split
16	16 R	16	Split	70/30	5	Split	None	--	Split	None	--	Shaved
17	70/30	16	Split	32 R	16	Split	16 R	5	Shaved	70/30	5	Shaved
18	70/30	5	Shaved	None	--	Split	32 R	5	Split	None	--	Split

[1]16 R = 16 percent residue creosote. 32 R = 32 percent residue creosote. 70/30 = 70 percent creosote, 30 percent coal tar.
[2]Retention in lb/cu. ft.

higher retention level than at the lower retention level. No other effect was attributed to the retention level of creosote in the wood.

Effect of Sample Preparation: The mean amounts of preservative extracted from machine-shaved and from hand-split samples of wood are shown in Table 8. It is apparent that the mean value of the amount of preservative extracted from hand-split samples extracted by the hot- toluene method is significantly less than that amount of preservative extracted from shavings, but no significant effect can be observed in the cold-solvent tests. Table 9 shows that extraction tends to be more thorough when the wood is shaved than when it is split, regardless of the preservative used. (This conclusion is corroborated by the data in Table 7, which show that in 9 out of 12 comparisons, more preservative was extracted from the shaved samples.)

Weight-of-Extract Method: *Effect of Extraction Method:* The room-temperature toluene and pyridine method extracted more preservative than did the hot-toluene method (Table 10). This difference, based on the weight-of-extract calculation, was more pronounced than the difference observed from the comparison based on the weight-difference calculation (Table 5). If the two negative values and the 1.9 value (all three of which are shown tc be significantly discrepant by probability curve) in Table 10 are omitted (as were the two negative values in Table 5), the average difference in preservative extraction is 0.8 pound per cubic foot, compared with a value of 0.4 pound per cubic foot from data in Table 5.

Effect of Preservative: Table 11 shows that the difference in the amount of preservative extracted by the cold-solvent and hot-solvent methods increases as the properties of the preservative change from low to high-residue content. This effect is apparent despite the effects of retention level or preparation of the wood prior to extraction.

Effect of Retention Level: Table 12 shows a definite tendency for the difference in the amount of preservative extracted by the cold-solvent and hot-solvent methods to be greater at the higher retention level. Also the data show that there is no significant difference between the two methods at the lower retention level.

Effect of Sample Preparation: In Table 13, the calculated mean amounts of extracted preservative are shown grouped according to sample preparation and to extraction method. It is evident from these data that more preservative was extracted when the samples were shaved than when they were split. When the data are shown according to preservative type (Table 14) it can be concluded that the sample-preparation method becomes a significant factor with higher-residue-content preservatives (illustrated by 70:30, creosote:coal tar).

Comparison of the Two Methods: Table 15 shows that the method used to calculate the preservative extraction significantly influences the results obtained. The average extraction calculated by weight difference is about 1 pound per cubic foot greater than that calculated by the weight of the extract. Because it appears that some loss occurs in recovering the extracted preservative, the weight-of-extract cal-

Table 5.—COMPARISON OF HOT- AND COLD-SOLVENT EXTRACTION FOR SHAVED SAMPLES, WEIGHT DIFFERENCE CALCULATION

Replicate	Preservative	Retention, lb/cu. ft.	Preservative Extracted,[1] pound per cubic foot: Hot-Solvent Extraction	Cold-Solvent Extraction	Difference Cold Minus Hot Extraction
I	16 percent residue creosote	5	3.4	3.6	0.2
		16	11.6	11.6	0.0
II	16 percent residue creosote	5	3.1	4.0	0.9
		16	11.4	11.9	0.5
I	32 percent residue creosote	5	3.7	4.1	0.4
		16	10.9	10.4	—0.5[2]
II	32 percent residue creosote	5	3.3	4.0	0.7
		16	10.8	10.9	0.1
I	70/30 Creosote-coal tar	5	4.0	4.6	0.6
		16	18.0	17.1	0.9[2]
II	70/30 Creosote-coal tar	5	4.5	4.7	0.2
		16	17.9	18.4	0.5
	Mean				0.4

[1]Data from Table 1, corrected for extractable resins.
[2]Not included in computing the mean.

Table 6.—EFFECT OF KIND OF PRESERVATIVE ON COMPARISON OF THE TWO EXTRACTION METHODS, WEIGHT-DIFFERENCE CALCULATION

Preparation	Retention, lb/cu. ft.	Difference in Amount of Preservative Extracted,[1] pound per cubic foot: 16% Residue Creosote	32% Residue Creosote	70/30 Creosote-Coal Tar[2]
Shaved	5	0.5	0.6	0.4
	16	0.3	0.1	0.4
Mean		0.4	0.4	0.4
Split	5	0.1	0.5	0.8
	16	—0.1	0.5	1.4
Mean		0.0	0.5	1.1

[1]Calculated from data in Table 1 by subtracting corrected values of hot-solvent extraction from corrected values of cold-solvent extraction. The "corrected value" is the value remaining after the observed value had been corrected for extractable resins.
[2]Contains 40.4 percent residue.

Table 7.—EFFECT OF RETENTION LEVEL ON COMPARISON OF THE TWO EXTRACTION METHODS, WEIGHT-DIFFERENCE CALCULATION

Extraction Method	Retention, lb/cu. ft.	Difference in Amount of Preservative Extracted,[1] pound per cubic foot: 16% Residue Creosote	32% Residue Creosote	70/30 Creosote-Coal Tar
Hot Solvent	5	—0.2	0.2	0.1
	16	0.3	0.3	2.1
Cold Solvent	5	0.2	0.3	—0.4
	16	0.7	—0.4	0.4

[1]Shaved-sample values minus split-sample values, calculated and corrected from data in Table I.

Table 8.—EFFECT OF SAMPLE-PREPARATION METHOD, WEIGHT-DIFFERENCE CALCULATION

Preparation	Mean Amount of Preservative Extracted,[1] pound per cubic foot: Hot-Solvent Extraction	Cold-Solvent Extraction
Shaved	8.6	8.8
Split	8.1	8.6

[1]Calculated and corrected from data in Table 1. The 95 percent confidence limits on each mean are the mean ±0.2.

Table 9.—EFFECT OF SAMPLE-PREPARATION METHOD ON EXTRACTION OF DIFFERENT PRESERVATIVES, WEIGHT-DIFFERENCE CACULATION

Preparation	Mean Amount of Preservative Extracted,[1] pound per cubic foot: 16% Residue Creosote: Hot-Solvent Extraction	16% Residue Creosote: Cold-Solvent Extraction	32% Residue Creosote: Hot-Solvent Extraction	32% Residue Creosote: Cold Solvent Extraction	70/30 Creosote-Coal Tar: Hot-Solvent Extraction	70/30 Creosote-Coal Tar: Cold Solvent Extraction
Shaved	7.4	7.8	7.2	7.4	11.1	11.2
Split	7.3	7.3	6.9	7.4	10.0	11.2

[1]Calculated and corrected from data in Table 1. The 95 percent confidence limits on each mean are the mean ±0.4.

Table 10.—COMPARISON OF HOT- AND COLD-SOLVENT EXTRACTIONS FOR SHAVED SAMPLES, WEIGHT-OF-EXTRACT CALCULATION

Replicate	Preservative	Retention, lb/cu. ft.	Preservative Extracted,[1] pound per cubic foot: Hot-Solvent Extraction	Cold-Solvent Extraction	Difference, Cold Minus Hot Extraction
I	16 percent creosote	5	3.1	2.8	—0.3[2]
		16	9.4	10.7	1.3
II	16 percent creosote	5	3.1	3.4	0.3
		16	9.8	10.8	1.0
I	32 percent creosote	5	3.4	3.6	0.2
		16	9.4	9.1	—0.3[2]
II	32 percent creosote	5	3.1	3.9	0.8
		16	9.7	10.4	0.7
I	70/30 Creosote-coal tar	5	3.6	4.9	1.3
		16	14.2	16.1	1.9[2]
II	70/30 Creosote-coal tar	5	3.8	4.7	0.9
		16	16.4	17.0	0.6
	Mean				0.8

[1]Data from Table 2, corrected for exrtactable resins.
[2]Not included in computing the average.

culation did not give as accurate an estimate of the amount of preservative present in the wood as did the weight-difference calculation.

Therefore, statements based on the weight of extract should be regarded as observed trends rather than conclusions. The relatively large size of this loss is attributable to the use of the microdistillation flask and the small-sized samples. When larger samples are used, more refined distillation equipment could be used and more accurate results would be obtained.

Table 15 also shows tha the cold extraction recovered more preservative than did the hot extraction. The validity of these data is not affected by the soluble wood resins extracted along with the preservative, for according to Tables 1 and 2, about the same amount of wood resin is extracted by cold extraction as by hot extraction.

The most accurate estimate of the amount of preservative present in a piece of creosoted wood is obtained therefore by extracting the preservative with cold toluene and pyridine and calculating the amount extracted by the weight-difference method. It has previously been shown that shaving the sample into fine particles prior to extraction improves the efficiency of extraction (Tables 8 and 13).

Table 11.—EFFECT OF KIND OF PRESERVATIVE ON COMPARISON OF THE TWO EXTRACTION METHODS, WEIGHT-OF-EXTRACT CALCULATION

Preparation	Retention, lb/cu. ft.	Difference in Amount of Preservative Extracted,[1] pound per cubic foot: 16% Residue Creosote	32% Residue Creosote	70/30 Creosote-Coal Tar[2]
Shaved	5	0.0	0.5	1.1
	16	1.1	0.2	1.3
Mean		0.6	0.4	1.2
Split	5	0.2	0.5	0.7
	16	1.0	1.4	2.6
Mean		0.6	1.0	1.7

[1]Calculated from data in Table 2 by subtracting corrected values of hot-solvent extraction from corrected values of cold-solvent extraction. The "corrected value" is the value remaining after the observed value had been corrected for extractable resins.
[2]Contains 40.4 percent residue.

Table 12.—EFFECT OF RETENTION LEVEL ON COMPARISON OF THE TWO EXTRACTION METHODS, WEIGHT-OF-EXTRACT CALCULATION

Extraction Method	Retention, lb/cu. ft.	Difference in Amount of Preservative Extracted,[1] pound per cubic foot: 16% Residue Creosote	32% Residue Creosote	70/30 Creosote-Coal Tar
Hot Solvent	5	0	0	0
	16	—0.2	0.3	2.8
Cold Solvent	5	—0.2	0	0.3
	16	0.3	—0.9	1.4

[1]Shaved-sample values minus split-sample values, calculated and corrected from data in Table 2.

Table 13.—EFFECT OF SAMPLE-PREPARATION METHOD, WEIGHT-OF-EXTRACT CALCULATION

Preparation	Mean Amount of Preservative Extracted,[1] pound per cubic foot: Hot-Solvent Extraction	Cold-Solvent Extraction
Shaved	7.4	8.2
Split	7.0	8.0

[1]Calculated and corrected from data in Table 2.

Table 14.—EFFECT OF SAMPLE-PREPARATION METHOD ON EXTRACTION OF DIFFERENT PRESERVATIVES, WEIGHT-OF-EXTRACT CALCULATION

Preparation	Mean Amount of Preservative Extracted,[1] pound per cubic foot: 16% Residue Creosote: Hot-Solvent Extraction	16% Residue Creosote: Cold-Solvent Extraction	32% Residue Creosote: Hot-Solvent Extraction	32% Residue Creosote: Cold-Solvent Extraction	70/30 Creosote-Coal Tar: Hot-Solvent Extraction	70/30 Creosote-Coal Tar: Cold-Solvent Extraction
Shaved	6.4	7.0	6.4	6.8	9.5	10.7
Split	6.5	6.9	6.3	7.2	8.1	9.8

[1]Calculated and corrected from data in Table 2.

Appendix A.—PERCENTAGE OF WATER IN SAMPLES EXTRACTED WITH HOT TOLUENE

Preservative[1]	Preparation	Retention, lb/cu. ft.	Water Extracted, percent: First Replicate			Second Replicate			Average
None	Shaved	--	7.8	7.8	7.5	7.8	8.0	8.0	7.80
None	Split	--	9.9	10.1	10.7	10.3	10.8	10.5	10.40
16 R	Shaved	5		4.3			4.7		4.50
16 R	Shaved	16		4.0			4.2		4.10
16 R	Split	5		5.5			5.6		5.55
16 R	Split	16		4.9			5.0		4.95
32 R	Shaved	5		5.1			5.2		5.15
32 R	Shaved	16		4.0			4.1		4.05
32 R	Split	5		6.4			6.5		6.45
32 R	Split	16		5.3			5.2		5.25
70/30	Shaved	5		5.1			4.7		4.90
70/30	Shaved	16		4.3			4.0		4.15
70/30	Split	5		5.2			5.7		5.45
70/30	Split	16		4.7			4.7		4.70

[1]16 R = 16 percent residue creosote. 32 R = 32 percent residue creosote. 70/30 = 70 percent creosote, 30 percent coal tar.

Summary

To provide a comparison between the two methods for extracting creosote from wood and to determine the optimum method of preparing the wood for extraction, a statistically designed series of extractions has been performed and analyzed by the Laboratory for statistically significant differences. Several indications resulted from this statistical analysis.

a) The cold toluene and pyridine method appears to extract more preservative than does the hot-toluene method. Therefore, the amount of creosote obtained by the cold extraction method is probably more representative of the retention in the specimen being examined.

b) Shaving the sample of creosoted wood to a fine sized particle permits a faster and more complete extraction than splitting the wood in the conventional manner. The more insoluble the preservative, the more value there is in shaving.

c) It appears that some loss occurs in recovering the extracted preservative. Therefore, calculation of the amount extracted by the weight-of-extract method did not give as accurate an estimate of the amount of preservative present in the wood as did the calculation by the weight-difference method.

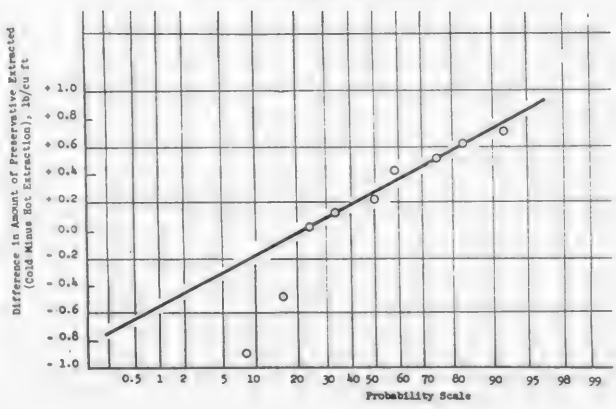
d) The amount of residue in the preservative has a definite bearing on the manner of preparation and the method of extraction that will be necessary to effect a complete extraction.

e) The retention level has a significant effect on completeness of extraction. At the higher retention level, the cold-solvent method accomplished more complete extraction than did the hot-solvent method. At the lower retention level, however, there is no difference between the methods of extraction.

Table 15.—DIFFERENCES IN EXTRACTION RESULTS DUE TO METHOD OF CALCULATION

Extraction Method	Mean Amount of Preservative Extracted, pound per cubic foot: Weight-Difference Calculation	Weight-of-Extract Calculation	Mean
Hot Solvent	8.3	7.2	7.7
Cold Solvent	8.7	8.0	8.4
Mean	8.5	7.6	8.1

Appendix B.—PROBABILITY METHOD FOR DETERMINING THE NORMAL DISTRIBUTION OF A SERIES OF MATHEMATICAL VALUES



To summarize, the best estimate of the amount of creosote in a piece of wood is obtained by shaving the wood to the finest reasonable sized particle, extracting it with cold toluene and pyridine, and calculating the retention by the weight-difference method.

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Pre-Pressing Plywood Assemblies[1]

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PRE-PRESSING CAN BE DEFINED as a preliminary application of pressure to a glued assembly which is not intended to produce final consolidation and cure. It is a brief pressure cycle at some point during a normal period of closed assembly time. The result is a glued assembly with sufficient temporary bond strength to remain intact through the usual handling and press-loading operations. It may also have improved bond properties.

Although many combinations of materials and adhesives are undoubtedly suitable for pre-pressing, the technique now being developed in the plywood industry is presented. The advantages, disadvantages, and operating limits will be discussed insofar as they are presently known. It is hoped that possibilities will be indicated for the successful application of pre-pressing within allied areas of gluing.

The concept of pre-pressing is not especially new. A patent was issued in 1942 to Mr. Harry Galber of I. F. Laucks, Incorporated, (now Monsanto) outlining most of the pre-pressing principles in use at this time. Preliminary cold pressing, followed by a kiln curing cycle, was discussed in another patent issued to Mr. C. N. Cone, also of I. F. Laucks, in 1934. In Russia and Finland, multiple pressing techniques were used in the manufacture of protein-bonded hot-press plywood before 1900.

There are at least several good reasons for pre-pressing plywood assemblies. It pays immediate dividends in production rate, gluing costs, and veneer recovery that make it definitely worth considering. Several advantages are:

1) Panel handling is made easier and press loading faster. Time savings can amount to an extra load in six or seven for hand-loading operations.

2) Panel rejects due to face veneer misalignment and breakage are sharply reduced or eliminated, especially with

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 6, Divisions 6 and 8. Glues and Gluing and Drying, June 20, 1961.

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The author presents a compilation of laboratory and mill experiences with preliminary cold pressing of hardwood and softwood veneers prior to final hot pressing. Also included is the effect of pre-pressing variables such as glue application rates, division of assembly time, pre-press cycles, plywood panel properties, and grade rejection rates.

automatic loading equipment. This is especially important for hardwood face veneers which are expensive and have a pronounced tendency to curl.

3) Precure time, with its adverse effect on adhesion, is substantially reduced.

4) Panel trimming margins have been reduced in some cases, yielding more complete and economical veneer utilization.

5) Lay-up or assembly time tolerance is definitely increased, permitting larger press loads and presses of greater capacity to be used.

6) Adhesive bond strength is improved, especially on difficult veneer, through better glue transfer and adequate penetration into both surfaces of each glueline prior to hot pressing.

7) Since both bond strength and assembly time tolerance are improved by pre-pressing, adhesive costs can be reduced for many applications through increased extension of the adhesive solids or the use of lower glue spreads.

Not all of these benefits can be realized in a single mill operation, of course. Glue spread reductions must be balanced against lay-up times, and bond strength requirements against glue extension. Also, an over-riding mill condition such as wet veneer may offset part or all of them. The general observation can be made, however, that at least several of these direct benefits from pre-pressing are available to almost every plywood manufacturing plant. As a result, the process warrants serious consideration.

Basic Variables

The basic variables of pre-pressing are few and simple; namely, stand time before pressure, pressing time, platen pressure, and stand time after pressure. Assuming for the moment that mill conditions are satisfactory and the veneer stock is cool, dry softwood, operating limits for each of these variables are suggested.

Stand Time Before Pressure: The application of pressure too quickly after lay-up almost invariably causes a reduction in bond strength due to excessive glue penetration. A stand time of about 10 to 20 percent of the permissible maximum assembly time limit for the glue being used has proved most successful. For example, stand times of 6 to 12 minutes are best for urea resin glues with a 60-minute closed assembly time limit. Stand times of 2 to 5 minutes are satisfactory for protein glues with a 20-minute assembly time limit.

Pressing time and pressure are heavily inter-related and are probably best considered together.

Press Time: Based on mill experience to date, a pressing time of at least 2 minutes is necessary, regardless of pressure, glue type or construction to obtain useful pre-press effects. Optimum press times appear to range from about 3 to 8 minutes. Within reasonable limits, the lower the pressure the longer the minimum press time needed for adequate glue transfer and the development of solid panels.

As glue spreads are increased, the minimum press time for effective pre-pressing also increases. Maximum press times are limited only by production rate, although no further benefits appear to be gained after the first few minutes of pre-pressing.

Panel thickness and construction appear to have little effect on pre-pressing time or pressure except in special cases, such as very hard, non-absorptive veneers, or very thin plies.

Platen Pressure: Uniform pressures of at least 25 psi appear to be necessary for solid pre-pressed panels. At these pressures, there is little effect on assembly time tolerance and bond quality, however. Pressures of 150 to 200 psi have generally been required for maximum bond strength and assembly time benefits from pre-pressing.

Pre-pressing appears to cause little or no permanent densification up to pressures of 200 psi and cycle times of 5 minutes or more. This does not apply to softer species such as redwood, western red cedar and sugar pine, for which pressures should be decreased in proportion to strength properties.

Stand Time After Pressure: This variable is simply the stand time remaining after pre-pressing until final press loading. It is usually a short period of time under normal production conditions, but can be made even longer than the permissible maximum closed assembly time limits for the glue being used if pre-pressing conditions are selected to favor assembly time.

As one might suspect, a number of other stock and mill conditions have a definite effect on pre-pressing limits and efficiency.

Veneer Moisture Content: In general, any level of veneer moisture content which is suitable for hot pressing will also pre-press satisfactorily. Excessive veneer moisture content interferes with pre-pressing by causing overpenetration of the adhesive and prolonging the press time required to obtain solid panels.

Veneer Temperature: Hot veneer has the effect of greatly decreasing the assembly time tolerance of most plywood glues. While prompt pre-pressing of a plywood assembly at 150 to 200 psi helps to offset this effect, hot veneer definitely shortens the maximum lay-up times which could otherwise be obtained by pre-pressing. It may also preclude the use of lower glue spreads, even with optimum pre-pressing conditions. Cold veneer is usually not a problem with respect to pre-pressing, unless the veneer is also wet.

Veener Peel or Condition: Within reasonable limits, loose or shattered veneer accelerates pre-press times and shortens permissible assembly time limits through its increased absorbency. Tightly peeled, smooth veneer from heavily steamed logs, for instance, has exactly the reverse effect and may require both additional stand

time and press time to yield solid panels. Excessively rough veneer is undesirable for pre-pressing due to its limited contact area and non-uniform pressure distribution. The adhesion on rough veneer is usually improved by pre-pressing, however.

Other frequently encountered veneer variables such as compression wood, white speck, incipient decay, overdrying, and thickness variation influence pre-pressing through their normal effect on adhesion. Pre-pressing usually improves the bond strength at least moderately in each case.

Veneer Specie: A review of the discussion thus far would seem to indicate that hardwood veneer species require more press time and stand time than softwood species to yield solid panels, just as non-porous species require more pre-press time than porous species. This is indeed the case. By properly selecting the pre-pressing conditions, however, the adhesion and handling properties of literally any type of wood veneer may be improved. Veneer species which have been successfully pre-pressed thus far include Eastern yellow birch, rotary and ribbon stripe Philippine mahogany, Sen and Shina (door skins), Western larch, Western hemlock, Douglas-fir from several areas, Idaho white pine, Ponderosa pine, redwood, and others.

Mill Temperature and Humidity: The daily temperature and also humidity in a plywood mill have a moderate effect on pre-pressing, due primarily to their effect on veneer condition. High mill temperatures yield warm stock, while high atmospheric humidity yields excessive stock moisture content after even a few hours of exposure. For instance, dry softwood veneer can increase in moisture content to as high as 12 percent near the ends of a stack if held overnight in a sea coast mill in southern Oregon.

Adhesives Used

Laboratory and mill experience to date have shown that almost any conventional hot-press plywood glue can be pre-pressed successfully under the proper conditions, although some glues are definitely more suitable than others by virtue of greater tack or flow properties. Protein glues made from soybean, blood and casein were the first adhesives to be pressed in this manner and are now being used in steadily increasing quantities to produce interior grades of hardwood and softwood plywood and also flush doors.

Urea resin adhesives, especially wheat flour-extended and melamine-fortified glue formulations, are being used very successfully with pre-pressing in the manufacture of hardwood faced and solid hardwood panels. Phenolic resin interior and exterior plywood glues are probably the most recent class of adhesives to be pre-pressed. Although they are generally less tacky than other types of glue, their flow properties have proved to be well-suited to the process. Recent additions of blood and wheat flour to both interior and exterior phenolic adhesives have helped to improve their pre-press tack.

A word of caution is in order regarding highly alkaline plywood adhesives containing proteins and amylaceous materials. Long storage of the mixed glues definitely reduces their pre-pressing efficiency through hydrolytic degradation, especially at higher mill temperatures.

Tables 1 and 2 show the effect of pre-pressing on the normal adhesive performance of typical protein interior and phenolic exterior plywood glues. The pre-pressing cycles were selected to give maximum improvement in assembly time tolerance and bond strength.

Equipment

Pre-pressing equipment may consist of nothing more than trim saw hold-down cylinders and bars, or it may be a specially designed full-sized cold press, depending on the purpose in mind. For instance, if only a light "tacking together" of the laid-up panels is desired for easier handling, minimum pressure and time cycles are needed. If, on the other hand, improvement of bond strength on difficult veneer, or a reduction in glue cost is desired, much higher pressures are a necessity. In addition to new equipment installations which are being planned, several of the plywood industry's cold presses have already been modified for pre-pressing applications.

Table 1.—EFFECT OF PRE-PRESSING ON THE PERFORMANCE OF (MONSANTO) NO. 1066 HOT-PRESS INTERIOR PLYWOOD GLUE

Pre-press time	TA before pre-press	TA after pre-press	Total TA	Dry shear test: Pre-press psi % WF	Dry shear test: Control psi % WF	Wet shear test: Pre-press psi % WF	Wet shear test: Control psi % WF
2 minutes	8 minutes	3 minutes	13 minutes	112–55	88–50	155–53	87–42
		8	18	158–65	92–37	160–65	103–55
		14	24	118–55	95–61	145–67	108–61
		20	30	98–50	130–61	78–75	138–63
		25	35	150–63	118–42	155–71	127–28
4 minutes	8 minutes	3 minutes	15 minutes	137–38	123–42	142–47	161–45
		8	20	138–61	161–57	163–71	157–58
		14	26	103–82	130–50	145–58	130–40
		20	32	103–80	103–51	123–60	88–37
		25	37	103–67	123–41	125–47	127–43
2 minutes	2 minutes	5 minutes	9 minutes	112–30	98–25	185–47	83–35
	5		12	138–65	105–75	227–65	88–63
	9		16	112–47	180–27	185–68	141–30
	15		22	110–61	108–42	100–45	155–42
	20		27	117–58	85–28	191–67	88–30

Panel Construction: 13/16 inch 5-ply Douglas-fir
Press Temperature: 285°F.
Press Time: 3¾ minutes
Platen Pressure: 175 psi
Glue Viscosity: 12,000 centipoises
Glue Spread: 88 lbs/MDGL
Precure: 30 seconds

Table 2.—EFFECT OF PRE-PRESSING ON THE PERFORMANCE OF (MONSANTO) PF4-D PHENOLIC EXTERIOR PLYWOOD GLUE

Pre-press time	TA before pre-press	TA after pre-press	Total TA	Glue spread	Shear test results: Dry psi % WF	Wet psi % WF	Boil psi % WF
None			3 minutes	58 # / MDGL	150–03	195–15	147–45
			15		218–53	278–77	223–73
			30		147–65	155–70	113–71
2 minutes	2 minutes	0	4 minutes	58 # / MDGL	160–71	155–95	120–92
		11	15		228–87	291–93	230–97
		26	30		245–73	167–95	157–93
None			3 minutes	65 # / MDGL	221–92	265–100	222–97
			15		160–57	150–73	120–78
			30		183–17	185–37	158–32
2 minutes	2 minutes	0	4 minutes	65 # / MDGL	213–83	195–93	140–98
		11	15		203–82	197–95	158–97
		26	30		193–70	178–80	145–82

Panel Construction: 5/8 inch 5-ply Tangile Mahogany (Marine Plywood)
Press Temperature: 285°F.
Platen Pressure: 175 psi.
Precure: 30 seconds
Press Time: 7½ minutes
Glue Viscosity: 1,100 centepoises

Equipped with rapid loading and off-bearing devices, they are placed in existing hot-press production lines between the lay-up area and the press. By proper arrangement, a single pre-press system can be made to serve two spreaders and even two hot presses.

Savings

As indicated earlier in the discussion, there are several areas of potential savings with a pre-press operation that can be used to amortize the cost of the equipment itself. The amount of these savings is so heavily influenced by individual mill performance, however, it is impossible to offer a general statement on rates of investment return. This much is known as a basis for calculation:

1. Glueline cost savings of up to 10 percent have been demonstrated.
2. Plywood grade rejects due to pressing defects have been reduced by as much as 95 percent.
3. Reductions on the order of several percent in veneer stock dimension due to smaller trimming margins have been claimed.
4. Increases in plywood production rate of 10 to 15 percent through existing equipment have been obtained.
5. Complete automation of press loading may be possible.

Assuming the installed cost of a pre-press can range from $8,000 to $40,000 depending on its design and condition, each plywood mill must determine from its own method of operation how large an investment can be justified by some combination of the pre-pressing economies listed above.

Other Benefits

As plant experience with pre-pressing continues to accumulate, certain of its benefits are emerging as the primary reasons for justifying its use. Clearly, first among these is the reduction of press rejects and easier, faster handling of the pre-pressed panels. These advantages alone have produced savings which justify its use on a purely economic basis. Glueline cost savings have definitely been obtained with pre-pressing, but generally through an increase in extension rather than a reduction in spreads. In a few cases, glue spreads with extended formulations have actually been increased to solve a particular adhesion problem, still at a net savings however. The assembly time limits for any particular adhesive have not been lengthened more than slightly by pre-pressing, but the average bond strength at both ends of the normal limits has been improved.

Improvement in bond strength due to pre-pressing remains a controversial question at this time. Examples of its failure to yield bond improvement on difficult veneer can be matched with examples of real improvement with other glues on equally difficult veneer. The answer to the question seems to rest with the adhesives themselves. Some glues are apparently capable of delivering their best adhesion without the necessity for pre-pressing, and, in fact, pre-pressing yields no further increase in bond strength. Other glues seem to have a bonding capacity which is not fully realized without pre-pressing, yet is satisfactory for conventional operation. Since there are hardwood and even softwood veneers which vary considerably in their bonding properties, the problem of improving adhesion on these veneers becomes an interaction between the adhesive, the pre-pressing operation, and the veneer itself. In this situation, pre-pressing alone cannot properly be counted on to deliver a major improvement in bond quality irrespective of the other variables. As a practical matter, however, pre-pressing has consistently shown at least a slight to moderate improvement in adhesion wherever it has been applied.

The best indication that pre-pressing is a valuable production technique for the plywood industry comes from the industry itself. The interest in and application of pre-pressing is growing at a rapid rate in the United States and Canada, paced by mills that have installed a prepress, and having observed the results firsthand, are installing others.

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Commercial Hardwood Veneer Drying Variables and Laboratory Correlation[1]

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DRYING IS THE FINAL PREPARATION of wood in veneer form for fabrication into plywood. The satisfactory completion of this process is of first importance to manufacture of a quality panel. The recurring troubles currently encountered by manufacturers and users of veneer and plywood show that room for great improvement exists in this field.

Variables Encountered in Drying

The large number of variables affecting the finished drying job has made conclusive observation quite difficult and evaluation of laboratory results for more than limited conditions often inaccurate. The equipment and personnel available in actual processing have not lent themselves to experimentation beyond simple trial and error. Lack of apparent relevancy of laboratory work to date has discouraged interest in this approach. A fresh look at the problem, based on both laboratory and commercial observation and their correlation, should prove fruitful in orienting future research.

Outside Factors: Species, variations within the species, and even previous conditioning during storage, cut-off and milling operations, heating, and cutting into veneer, can have as much effect on results in drying as the drying conditions themselves. These factors cannot be overlooked in consideration of the overall problem.

Dependent Variables: Secondary variables such as actual temperatures of the wood itself during processing, temperature and moisture gradients induced by conditions, and rates of change, particularly at critical points in the drying process, must be scrutinized for their effects on internal stresses and other factors.

Processes Used in Commercial Veneer Drying

Thin Veneers: A brief description of contemporary drying machinery may assist in visualizing the drying process. For thin veneers, up to about 1/16-inch thickness, a continuous conveyor is used, above and below the veneers, to carry them through a tunnel where they are exposed to varying conditions of heat, humidity, and forced air ventilation. A small amount of restraint, up to about 5 pounds per square foot, is usually present in the conveyor structure.

The Hot Plate Press: In direct apparent contradiction to the conveyor dryer is the hot plate press, consisting of a number of heated platens between which the veneer is held in bundles of one to twenty sheets under pressures up to 150 psi. Developed mainly for gluing operations in plywood plants, it is largely used here as a redryer, for conditioning of wood preliminary to gluing operations, and for flattening of buckled stock.

The High Restraint Dryer: Bridging the gap between the hot plate press and the conveyor dryer is the high restraint dryer, used for heavier veneers from 1/16 inch up. The veneer passes between rollers through a heated tunnel. The weight of the rollers restrains warping and buckling and produces a casehardened effect that gives best results in most woods. This extreme casehardening cannot usually be tolerated in thinner veneers however. An interesting variation of this dryer moves the veneers through heated platens which alternately open and close and move horizontally as well to move the wood.

Correction of Drying Defects

Stress relief methods such as the use of the hot plate press, and moisture conditioning of various sorts, are proving to be adequate means for preparing wood for the final gluing process. However, they all cause additional expense, and improvement of drying methods to minimize this extra processing should more than compensate the effort required. It should be noted here, however, that conditions encountered during storage or transit of veneers can cause defects sometimes blamed on the drying process.

Operational Factors

Continuous Conveyor Dryer: In the operation of the continuous conveyor dryer, temperatures up to 300° F. are used, but normally range between 220° F. and 275°. Higher temperatures are seldom practical as steam sources in contemporary hardwood veneer mills usually are limited from 100 to 125 psi. Two zones are often provided with individual controls to give a better process. The drying curves follow those shown by Fleischer (2).

Introduction of humidity at the early part of the process has in some cases apparently reduced the amount of buckle which occurred. This would increase the initial upward slope of the wood temperature curve in the beginning, but cause it to level off more quickly. Increased circulation rates cause a higher drying rate with a lowering of the wood temperature at a given air (dry bulb) temperature, throughout the cycle (1). Sufficient restraint provided at the temperatures noted above will, as shown by Kuebler (7) reduce buckle due to casehardening stresses to a minimum. These three effects, i. e., 1) introduction of humidity early in the cycle, 2) higher circulation rates, particularly with higher temperature, and 3) restraint, are the only ones which have proved useful to any degree in control of buckle and other drying defects of

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 6, Divisions 6 and 8, (Glues and Gluing and Drying), June 20, 1961.

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The author identifies, classifies, and relates the variables that affect commercial hardwood veneer drying processes, in the light of both commercial and laboratory experience. They fall generally into three classes: 1) the wood itself, 2) physical conditions established within the dryer, and 3) secondary conditions established as a result of interaction of the primary conditions.

this type. Full control of buckle or checking due to tension wood (6) has not been achieved. This has been demonstrated repeatedly in all thickness from 1/85 inch, where springwood and summerwood cause a short wave "cockle" buckle, to heavier stock and lumber. Complete control of this type of shrinkage defect is only possible under highly plastic conditions and heavy restraint which can be obtained in the hot plate.

The High Restraint Dryer: In the high restraint dryer a cycle similar to the continuous conveyor machine occurs. Direct contact with the rollers causes a different surface effect and casehardening occurs to a far greater degree than in the conveyor machine. The restraint provided is sometimes insufficient to eliminate all buckle and the type that results resists further efforts such as use of the hot plate press to reduce this condition.

The Hot Plate Press: The hot plate press functions by heating the wood to a plastic condition and then deforming it into a flat sheet. If wood is too dry when pressed it will check and fracture due to lack of flexibility. In any case it is necessary to "breathe" the press to permit release of steam developed.

Buckle

The most important dryer defect today is buckled veneer. Most buckle is due to the following causes:

1. Tension wood
2. Longitudinal sets (induced)
3. Lateral sets (casehardening)

Casehardening from heat alone has been thoroughly analyzed as it affects tangential and radial shrinkage (3, 7). Its effects on longitudinal shrinkage have not been so analyzed nor has the type resulting from pressure and roller contact as in the high restraint dryer been studied.

Normal Buckle: Tension and compression wood buckle are the result of non-uniform longitudinal stresses in the wood, hence the term "normal," their origin coming from the wood itself (6). Relief of these stresses must be achieved if best results in final gluing operations are obtained. It is in this area that most dryer problems occur in all types of drying, and in which results are most affected by all the previously mentioned variables. Experimental work to date does not offer more than identification of the cause of these stresses (6) or indicate any particular line of attack to the problem in this regard.

Induced Buckle: In wood not classified as tension wood, buckle due to other causes is occasionally found. This type can only be the result of improperly controlled drying, and is usually found when one part of the sheet of veneer tends to dry faster than another. Often difficult to identify as such, it can be mistaken for normal buckle when the causes are not apparent. The most pronounced types are end buckle, resulting from more rapid drying in the ends of the sheets, and storage effect, where the exposed sides of the veneer dry slightly before being placed in the dryer. This causes the outside to dry more rapidly and shrink more longitudinally than the inside. Other types of induced buckle are caused by such factors as uneven heating and circulation, and are less easy to classify, sometimes only being evident when one dryer develops a higher proportion of buckled wood than another.

Variations Among Hardwoods

Some idea of the differences encountered in hardwoods alone is shown in the table.

Notable Drying Problems

Several observations lead us to believe that processes may be varied to improve results. The simplest is the end buckle, most noticeable in rotary poplar, which is caused by the ends of the wood drying more rapidly than the body of the veneer. More shrinkage occurs in the slower drying part, confirmed by Kuebler (7). This effect has been studied thoroughly by Lutz.

Walnut veneers are usually held from 24 to 48 hours between cutting and drying to achieve a desired uniformity of color. During the actual drying process the sides are noted to shrink longitudinally more than the middle, resulting in a buckled condition. This is the result of the sides drying during storage, and stresses induced by the moisture differential created causing uneven shrinkage. This defect is corrected in practice by sprinkling the sides of the veneer with water and by keeping the wood covered with tarpaulins, or both, while seasoning.

To illustrate the effects of outside variables are several familiar cases. Rotary cut veneer will dry up to 15 percent faster than sliced veneer, and loose cut veneer will dry faster than tight cut wood. This complicates drying schedules, and causes variations in shrinkage where one part is tighter cut than another. Time of the year cut and subsequent conditions of storage will affect the amount of moisture present in the log, and hence in the wet veneer. Some observations seem to indicate that the lower the moisture content of the log, the less differential in longitudinal shrinkage rates between springwood and summerwood during drying. It has not been possible to accurately establish this effect. It is noticeable in sawing of hardwood lumber that the sapwood or outside of the log appears to be in tension, resulting in a bowing effect in the boards or cants made with the heart off center, particularly with spring cut timber. This will sometimes cause, in walnut and in other woods, the same effect as drying of the sides of the veneer, but the previously mentioned treatment will not improve results.

Casehardening

Casehardening, Normal: Lateral stresses caused by mild casehardening are of relatively minor concern. It has been established that buckle from this source can be corrected by a small amount of restraint using pressures not exceeding 5 pounds per square foot in veneers under 1/16 inch. However, it can complicate the effects of other types of buckle and make them more difficult to control.

Casehardening, Mechanical: In the high restraint dryers the direct contact with the heated rollers causes a plasticizing effect in the wood and a longitudinal compression effect on the surfaces of the veneer. This sometimes results in a long wave buckle which is almost impossible to press out, and which can result in difficulties in gluing up the plywood.

Miscellaneous Problems

Other defects not associated with the mechanical behavior of the wood are black marking from contact with

DRYING CHARACTERISTICS OF COMMON HARDWOODS

Species	Dryability	Remarks
Ash	Good	
Basswood	Good	
Beech	Poor	Extremely hard to remove any sets that occur; subject to continuing marked changes with seasoning, even after gluing into plywood.
Birch	Good	Tension wood in heartwood.
Butternut	Fair	Soft; marks easily; some buckle.
Cherry	Good	
Cottonwood	Good	Occasional tension wood buckle.
Elm	Poor	Usually severe buckle in plain sliced and rotary cut.
Gum, Red	Fair	Color marks easily; moderate buckle.
Gum, Black	Poor	Extreme buckle.
Hickory	Fair	Moderate to heavy buckle.
Magnolia	Good	
Mahogany	Good	Frequent tension wood buckle; occasional marked "hard streaks" or bands of heavy tension wood; grain variations sometimes cause induced buckle (applies to most African and Central American hardwoods).
Maple, Hard	Good	Resembles beech but less severe.
Maple, Soft	Fair	Same as hard maple.
Oak, Red	Good	Occasional tension wood and induced buckle.
Oak, White	Good	Same as red oak.
Pecan	Poor	Uncontrollable tension wood.
Poplar	Good	Induced end buckle.
Sycamore	Good	
Tupelo	Fair	Similar to black gum.
Walnut	Good	Subject to tension wood buckle; also induced buckle.

steel conveyor elements, checkerboarding discoloration results from nonuniform circulation at the surface of the veneer, and others of less importance. Checkerboarding is particularly prevalent in sweet gum veneers dryed in continuous conveyor dryers, where irregular circulation around the conveyor parts and, possibly, radiation, cause the outline of the conveyor structure to be imprinted on the veneer. Also mentionable in this category are splits and checks caused by excessive or poorly distributed restraint. These are mostly found in the hot plate press, when wet veneer is held too long without allowing it to equalize, or dry veneer is pressed beyond its capacity to flatten out.

Today's Drying Machinery

Today's dryers are quite adequate from an efficiency standpoint, with ratios of less than 2 pounds of steam per pound of evaporated moisture, in the more common types. While significant improvements in drying rates can result in economies in costs of structure, floor space required, and labor costs of operation, improved quality is the most important goal to be achieved. Electric drying, dielectric drying, vacuum drying, and several others have been tried experimentally but cost has completely blocked any useful development along these lines. Suction restraint has been tried in a contemporary European dryer but the uncontrolled airflow resulting causes unpredictable results. It would seem, then, that refinements in present types of commercial dryers, based on both industrial and laboratory experience, offer the best chance for progress in this important phase of woodworking.

Program for the Future

Due to the nature of the variables involved, further experimentation on a laboratory scale does not look promising. Close control and careful observation by trained personnel on a commercial scale with statistical interpretation of results should give a better opportunity improving our drying operations. An ideal arrangement would be to have two dryers, identical in all respects, side by side. A standard procedure yielding results acceptable to the present trade should be established, to provide a norm. To evaluate deviations from the standard cycle the following procedure would be used:

1. Separate the flitches or bolts of veneer into two units, alternating sheets to provide exact similarity at this point.

2. Dry the two units in the two machines, one to the standard cycle and the other to a cycle modified as desired.

3. Observe and evaluate results. a). Establish time, temperature, and moisture content curves as shown by Fleischer (2). b). Identify types of buckle and other defects developed. c). Determine shrinkage, longitudinal and lateral, which occurs.

In conducting tests by this method, the following variables should be investigated:

1. Dry bulb temperature, each zone.
2. Wet bulb temperature, particularly at the head end of the dryer.
3. Air circulation (rate and distribution).
4. Amount of restraint from conveyor elements.

The following items should be noted as affecting results: species; specific gravity; initial moisture content; final moisture content; drying time; special conditions, which include compression or tension wood, end grain, cutting, and other factors; and thickness.

Graphs of wood temperatures and moisture contents against time (2) should give a picture of the effects of these variables and their relation to each other. It is probable that differences would be found between species but that marked similarities in cause and effect would be noted.

Conclusions

It would appear that with the present background of laboratory experience and practical knowledge available that a program incorporating both sources of information would materially improve the quality of drying and reduce the cost, or both. Due to the large number of variables involved, a commercial scale with closely controlled and observed conditions should give best results. Experience gained in large scale tests should improve all operations concerning the manufacture and use of plywood.

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Product Development--- Keystone to Expanded Markets[1]

C. B. DOSKER
Gamble Brothers
Louisville, Kentucky

IN THE FOREST PRODUCTS INDUSTRY, there is an appalling lethargy with which the industry faces its multitude of problems. There is unbelievable resistance to change, to departure in any phase of the industry from procedures of the past. This is particularly true in the manufacture of board lumber. On other occasions I have called this situation "industrial grandpappyitis." There are other industries that have suffered from this disease and have departed from our midst. Think of the wagon manufacture who could not believe automobiles would succeed. The railroads are currently suffering, as are we.

Need for Technology

How do we awaken this giant forest industry to the opportunities before it? For generations, as an industry, the forest products industry has been known as a non-technical one. For centuries wood has been a raw material for the craftsman. That day is over. Today, with the new processes available to it and the new products resulting, wood has become an engineering material. The forest products industries must continue to become more technical in all of the segments. The new approaches to merchandising must be the technical approaches. The new approaches to manufacturing processes must be technical, and there must be new and cooperative approaches to both basic and product research. I say the need for this cooperative approach is urgent because the forest products industry, for the most part, is composed of small units of capital, and resources for research need to be pooled. In the planning of projects for cooperative work, this Society could play an important part. It is a phase of this Society's overall activity that needs careful scrutiny by the Board. The industry is in jeopardy; it is later than we think.

We are all familiar with the slogan of the General Electric Company "progress is our most important product." As an industry, we need to do some soul searching. In our thoughts there should constantly be that thought that progress is also our industry's most important product. The National Wood Promotion Program, sponsored by the National Lumber Manufacturers Association, is a major endeavor by the lumber industry toward progress. This program is making our country wood conscious. The establishment of a new production management division of this society is also another forward step that will aid in bringing into use, and being, new processes already available to our industry.

As technical people, it is not necessary for me to tell you that the world we are living in today has become a technological maelstrom. New knowledge, making possible many new products and improvements on old products, is becoming available much faster than it can be absorbed. The normal processes of industrial evolution have given way to industrial revolution. A new product or a new process can come from an industrial laboratory today and destroy, almost overnight, a market of long standing for an established raw material, or product, and can make equipment of high capital value obsolete and practically worthless in a matter of a few months.

C. B. Dosker, keynote speaker at FPRS 15th Annual Meeting.

Consider the management of a business today as smart and well-posted if they can keep track of new developments that are taking place in their own industries without considering developments in those industries whose products materially influence the established markets of their business.

20th Century Industrial Revolution

There are many reasons given as the cause of the industrial revolution of the twentieth century. I, personally, agree with those who feel the major cause has been the radical changes that have taken place in the fields of communication and transportation. These two industry groups were greatly stimulated by World War I. It has been said that research done during this war advanced, by at least 25 years, the normal rate of development in these two fields. The 10 years

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[1] Keynote address presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., June 19, 1961.

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Product development is the means of expanding and retaining markets. It is not only the keystone but also the foundation stones upon which the arch of survival of the great forest products industry rests.

that followed World War I saw the mass production techniques used in production of war materials applied to mass civilian markets. The popular-priced automobile, over-the-highway motor transportation, commercial aviation, radio and television all had their beginning in this period. New industries were born to serve the needs of these expanding fields of transportation and communication.

World War II, with more research, with more advanced technology, has again accelerated research and product development. The needs of war produced tremendous expansion of facilities, particularly in the fields of light metals and synthetics. Nuclear physics, with all the implications of both good as well as destructive uses, has created a new era. Technology has advanced to a degree that has passed the comprehensive capacity of too large a portion of the population. That is why I said previously we are in a technological maelstrom.

We must realize that since the end of World War II there has been a tremendous urge on the part of the industries, who own facilities created for military needs, to utilize these facilities for peacetime markets. As a result, there has been much research, out of which have come many products that are encroaching upon old and established markets of the forest products industries. Wood has been losing heavily in this struggle.

Funds Spent in R and D

I think it would be well to take a look at the amount of funds that have been spent in research and development effort since World War II (table). From 1950 to 1961 there has been more than a 400 percent increase in research expenditures. Do you wonder our markets are suffering? Of this tremendous research expenditure, about one-third of the total is being expended in missiles and aircraft. I have said that part of the industrial revolution was brought about by developments in the field of communications. Almost 24 percent of the research funds have been spent in electrical equipment and communications.

In machinery, 9.6 percent was spent, but practically none of this was spent in the development of new woodworking machinery. Eight percent was spent in the chemical field—more competition from plastics. Almost 3 percent was spent in metals and metal products. How are we in the forest products industry meeting this challenge? Where do we stand in this battle? We must remember that our industry sells 15 billion dollars worth of merchandise a year. Our industry represents 20 percent of all business enterprise, it employs 10 percent of all those gainfully employed in manufacture. What does it spend in research? According to the "Business Facts Book" of the National Industrial Conference Board, the lumber and timber products industries spend less than one quarter of 1 percent of sales dollars on research. The pulp and paper industry does a little better. They spend about one-third of 1 percent of sales dollars on research. This is to be compared with the average expenditure by other major industries of more than 1 percent of sales dollars. This means, by the method of calculated "guesstimating," that the entire expenditures for research and product development in the forest products industries lies somewhere between 50 and 75 million dollars a year. As an industry, we need to have accurate figures, and to obtain these figures should be a major objective of this Society. We must all admit that the word "puny" inadequately describes our percentage of research dollars to the total spent by industry in this country.

With this knowledge of research expenditures at hand, it is easy to understand why the per capita consumption of lumber is steadily declining. With a population increase from 150 million in 1950 to 180 million in 1960, the same 10 years saw a per capita decline in lumber consumption from 268 board feet to 204 board feet. Why? "Grandpappyitis." It must be so, for growth and drain are in balance. We have saw timber, we have timber for fiber, and for veneer. By intensive forest management, growth rates can be materially increased. Timber is a renewable resource. A strong and healthy forest products industry is essential to our national welfare.

I have said before, the whole industry needs an awakening. It must develop a strong feeling of "togetherness" in this drive to hold and expand markets. There are many causes for the decline in lumber consumption. Over the years, continued lowering of grade quality standards is causing a considerable shift in lumber use. This shift is not only between grades in a single species, but also a shift in species. Users of lumber do not buy grades, they buy utility. The producers do not seem to understand this fact. We cannot merchandise with methods that have not changed in 50 years. As markets decline, intense competition within the forest products industries is springing up for the ever declining markets. This is no sensible solution to our problem.

Heed Customer Wants

What can we do? Let's come out of the woods where we can see only trees. Let's come all the way out into the sunlight, where we can see the markets we serve and the methods to serve them. If we are willing to be critical of ourselves, if we will look at the markets closely and study them well, we will suddenly come to a great realization. This realization is the fact that there is no basic material available to industry in this country that is as flexible for conversion into production materials for building, or for industry, as a log. It can be used as a log. It can be sawn into boards of any thickness to meet the specific needs of a given product. When felled, a tree can be cut to the desired and needed lengths of a specific product before sawing, or cutting into veneer for specific use. Part of our marketing problem of today is the need for reduction of waste in conversion. You can readily see the procedures I have outlined above can reduce waste in conversion. If a customer wants a board sawn seven quarters, you can do it. If he wants lumber 9 feet, 3 inches in length, you can do it. You may not want to, but you can.

The time has come when we must consider customer wants. The days of sawing lumber the way we want to, and then saying to our customer "come and get it" are rapidly passing. What I am talking about is one kind of product development that takes only slight market research, your customers' needs. Study them well while he is still your customer.

We are losing many markets through sheer indifference. If you have a customer who needs technical help, give it to him. If you have to hire technical help to aid him, do so. The day has passed when, as an industry, we can afford to use untrained, technically incompetent, sales personnel against trained sales engineers, selling com-

petitive materials. It does not mean that the competitive material is better than lumber, or that it is even its equal. Knowledge of the physical and mechanical properties of materials is necessary today in the design of a product. In many cases today, lumber loses out, and a shift to some other material is made simply for lack of an insignificant bit of technical information. The use of minimum sizes can produce great savings. There is great need for technically trained sales personnel in the forest products industries today—men who can go to a builder and aid him in the design of his building, or men who can go to a manufacturer and advise him on the grade and species of lumber best suited for his product and why. In this day and age, how can we expect people to use wood if we do not give them technical assistance?

Significant Developments

The Forest Products Laboratory now has a pilot study underway which can be of significant importance to the industrial users of hardwood lumber. This pilot study will develop the method for preparing utility charts that will give the percentage of yield that may be expected in the production of wood parts in clear two sides, clear one side, paint and core grades, in length classifications, when various grades or hardwood lumber are used to produce the cuttings. Today lumber is an unassayed material. When you can predict yield by quality and size from a given grade of lumber, you take the guess out of lumber as a raw material. When this is done, the so-called low grade lumber problem will vanish. This kind of effort and the results it can accomplish are what I call significant product development in hardwood lumber.

MILLIONS SPENT IN RESEARCH AND DEVELOPMENT SINCE WORLD WAR II

Year	Government	Industrial	University	Total
1945	430	990	100	1,520
1950	570	1,980	320	2,870
1955	1,000	3,950	450	5,400
1958	1,380	8,100	750	10,230
1960				12,000
1961				14,000+

Much progress has been made in adhesives for use with wood. I look for the day when the common nail will be completely obsolete. Gap-filling resins and contact adhesives are not for the future, they are here. You can now say, "don't nail it, don't screw it, it's faster to glue it."

Dimensional stability of wood has been somewhat of a problem. Ethyllene glycol is one answer. There will be others. The protective coating industry is working full steam on this, and I have seen some film coatings with tremendous potential. Reduction of combustibility, fireproofing of lumber, chemical utilization of wood, these are in their infancy.

More products are and can be made from trees than any other raw material. Let us not be concerned by the number of species, let us take full advantage of their varying mechanical properties. Through glue bonding, many formerly impossible things can be accomplished. We have great material advantages. These can be made even greater by combining wood with other materials for industrial use.

Let us not forget basic research. This is also greatly needed. This must and should be done largely by public and university laboratories.

Meet the Challenge

Let the forest products industries, through this Society, bring on its dreamers, its "imagineers," its engineers, its creative thinkers, and let us work out plans to hold what we have and recapture what we have lost in markets. Product development is a two-edged sword. One edge is that which protects existing markets by redesign of product, by better engineering and by better sales methods and customers' relations. The other edge is the carving edge. With this edge, we carve out new products from existing knowledge and new knowledge, rapidly being acquired. New products we will, and can have, to meet the needs of an every hungry and ever growing consuming public. Product development is the keystone that will provide the future strength of the forest products industries. The Forest Products Research Society and its membership must accept this challenge.

Book Review

Frey-Wyssling, A.: Die pflanzliche Zellwand. (The Plant Cell Wall.) Published by Springer-Verlag, Berlin-Göttingen-Heidelberg, Germany, 1959. 367 pp.

Professor Frey-Wyssling of the Federal Technological Institute at Zurich, Switzerland, who has been doing research in the field of fiber structure for more than three decades, presents a comprehensive survey of the present status of knowledge of the plant cell wall. An appreciable share of this knowledge is the result of the skillful investigations of the author and his students and colleagues. Consideration of the techniques of electron microscopy, x-ray analysis, polarization microscopy, and physical chemistry affords an excellent over-all picture of the origin, structure, and properties of the plant cell wall.

The book is divided into three main parts—biostructure and biogenesis, biochemistry, and biophysics of the cell wall. The first section deals with the developmental history and variation in shape of the cells. The second section considers the chemical nature of cellulose, lignin, hemicelluloses, pectic substances, gums and mucilages, waxes, and related materials found in various cell walls. The last section treats fully the x-ray and optical methods of research; the density, shrinkage and swelling, and strength properties of fibers and wood and their complex relationships with wall structure are also discussed.

This volume is well illustrated with line drawings, photomicrographs, and electron micrographs. It will be a valuable reference book for the biologist, plant biochemist, and fiber expert.

I. H. Isenberg
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Revitalization Through Modern Marketing[1]

A. B. HOOD
President
National Lumber Manufacturers Association

The progress made in modern marketing is all tied into the years of conscientious scientific investigation and research done by forest products men. The lumber industry has now begun to act upon the advances made, as cited in this article by one of the leaders in the industry.

MODERN MARKETING is a fairly exact science. This is demonstrable in the case of the lumber industry. Of course in no field—whether research, education, promotion, merchandising, or what have you—is anything foolproof. For example, consider the case of the father who asked his son: "What happened to that waterproof, unbreakable, antimagnetic watch we gave you for Christmas?"

The son's answer was: "I lost it."

As they say in space circles, there are always uncertainties between lift-off and splash-down, but we now have a marketing program in the lumber manufacturing industry that is in its third year and that is constantly being re-evaluated and checked off. Nothing has been left to guesswork, not even educated guesswork.

I can assure you that this program is successful. You don't have to be told that lumber manufacturers have "show me" minds. The fact that they have voluntarily increased their support to $2,000,000 a year is one bit of evidence to be taken into consideration in building a case to show that this industry is regenerated, is revitalized and can out-plan, out-think, and out-maneuver the competitive materials that were so long practically unopposed by wood in modern marketing techniques.

Marketing begins with the product to be sold, of course—not with the advertisement that tells about it. But the very product has been revitalized. And its impact has been revitalized.

The nationally known marketing publication, *Printers Ink,* made this comment about our industry advertising: "A thoughtful and imaginative approach investing the familiar uses and potential of wood with a new excitement." Actually, the basic excitement going on in wood today lies in the fields of research, wood technology, wood engineering, data development, and technical assistance at all levels throughout the country where the use of wood is at stake.

But before I get into the principal divisions of our marketing program—the National Wood Promotion Program—let me mention just one project, long talked about but now acted upon. You will be interested because the Forest Products Research Society has carried the ball over the years in attracting students to curricula in wood technology and wood utilization.

At our spring Board meeting last month, our Special Committee on Technical Studies recommended the establishment of four graduate fellowships in timber engineering at $3,000 each. I feel sure this will be given serious consideration at our Annual NWPC Meeting in November, and if approved would go into effect in 1962. This program will probably begin at the University of California and subsequently be rotated among other regions.

The Forest Products Research Society has also been most active in our National Wood Council and in helping chart the course of our industry-wide program. Underlying all this, however, is the research initiative and technological progress in forest products coming out of your individual plants and laboratories.

Promotion

Usually when we start talking about the wood promotion program, we start talking about promotion first. This program is far more realistic than just going around saying "wood is good."

More than half of our budget for the coming year goes into technical investigations and technical promotion. Inroads by competitive materials make it mandatory that we have a technical development program directed to specific projects which are of the greatest importance to the entire lumber industry. Our NLMA policy is that these projects should serve to develop supporting data for the promotion and sale of lumber and wood products, leaving basic research to public bodies and product development to individual companies.

Twelve technical projects are staked out for action in the coming year's program. The first three projects are already underway. One of these will be completed this year—a standardized system of component construction and a basic manual on which its technical promotion will be based.

Evaluations of floor systems to provide a method of construction which will be more competitive with the concrete-slab floor will be continued. Tests on railroad bridge stringers un-

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[1] An address presented at the 1961 Annual Meeting of the Forest Products Research Society, June 19, 1961.

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der repeated loading have been worked out and will be continued.

For project number four, the NLMA Board of Directors has authorized a special subcommittee consisting of one technical and one manufacturing representative of the principal agencies publishing grading rules for softwood lumber to develop a simplified system of grade names and basic grade descriptions for softwood lumber for residential, light framing, and general construction application. This committee has been directed to meet within 60 days and to stay in continuous session until unanimous agreement is reached. Considerable spadework has already been done on this objective. Action of this kind has one great over-riding signifiance—and that is that when we attack problems in continuous session, we mean business.

Briefly the other undertakings are a study of new methods of assembly, load distribution in multiple member assemblies, and improvement of information on fasteners; improvement of FHA valuation for frame houses; the graduate fellowships in timber engineering already mentioned; fundamental studies on the burning of wood; development of a more accurate method of determining the strength of lumber; establishment of fire resistance ratings for wood construction; development of methods to provide improved performance for finishes on exterior wood; and, finally, collection of fire loss data on unprotected metal buildings.

Now, in addition to this, our Association is laying the groundwork for a much broader program for development of new wood construction systems, generally labeled as a program of wood engineering and construction technology. This program has been recommended by the Economic Council of the Lumber Industry—which is our long-range planning brain trust—and practical plans for it will be submitted at our November meeting.

Accomplishments

Now, for a little evidence on things already accomplished—proving that what we knew to be correct about wood's superiority is scientifically supportable. We knew that wood had natural insulating characteristics but we had never supported our position with our own test data.

At present we have two test houses at Beltsville, which are fully instrumented to measure the effect on both heating and air conditioning costs of wood frame construction versus masonry construction. Preliminary results already prove that wood frame construction provides a 25 percent reduction in heating costs and an 18 percent reduction in air-conditioning costs.

Similarly, we knew that wood joists could outperform unprotected steel joists in the face of fire.

Now, we are showing throughout the country—to building officials, school officials, the fire insurance people, builders, architects, mortgage company personnel and everybody else who should know, a color motion picture. The picture shows carefully conducted tests at Southwest Research Institute. The tests demonstrated that after 13 minutes of exposure to 1,500 degrees of heat and flame, the roof section supported by steel joists collapsed. The identical roof section supported by wood joists remained firm, 80 percent of the cross section remaining unburned and available to carry load.

Armed with this kind of technical information and a great array of other technical literature, films, exhibits and so on, our field men are penetrating the construction market at the local level on an extensive scale. In a recent 25-working day period, our technical men held wood school clinics in 24 cities attended by 2,500 school influentials.

From these men we are consistently receiving reports of a new awareness of wood, a new demand for authoritative information on wood use, an eagerness to use wood in new and unusual ways, in different forms, and in dramatic beauty.

Architects have re-learned wood's versatility; they have been brought abreast of recent developments; they have offered the greatest endorsement a product can have . . . increasing acceptance by the front runners in the area of modern design. Seventeen of the 20 houses selected by *Architectural Record* as the outstanding houses designed in America in 1960 were marked by major use of wood in a wide variety of ways. The shelter magazines have reawakened to wood and its virtues, with page after page of editorial features, with extensive photographic illustration.

We have had requests for as many as 123,000 publications in one month at our National Wood Information Center. In our advertising program, from its beginning, we will have had by the end of this year 325 pages for wood in 202 issues of top magazines for our prime target audiences. In its March 17th issue, *Life Magazine* carried to the American consumer the 150 millionth page of our full-color advertising in that magazine. Both this advertising and that in architectural, builder and school publications, have been scientifically evaluated and we know they are hitting the mark.

ARTHUR B. HOOD, NLMA president, called for . . . suggestions, criticism, guidelines, and participation from FPRS.

The aim of all this—in technological development, and in advertising and sales promotion—is simply to satisfy the consumer so that we may continue in business at a profit and contribute our share to the nation's productive economy. And we are quite important to that economy because we create wealth—we do not just trade in the same dollars.

In giving the ultimate consumer an attractive high-performance structure, in enabling the builder to hold costs down, in giving the architect an engineered material of great design flexibility, we are exercising the true marketing function. In getting wood used as a modern material with modern techniques and in overcoming outmoded regulations handicapping wood use, we are engaged in marketing.

One inspiring result of this program is an intra-industry unity that many thought impossible only a few years ago. There are 54 organizations in our National Wood Council.

And there are more than 500 companies, individuals, and groups voluntarily contributing more than $100,000 a year at present. So many people find this program such a revelation when they hear about it that they want to put something in the collection plate right away. We would prefer they not do it that way, however. We would like for them to do a little sustained thinking about it, first—and then participate on a sustained basis.

New Effort

There is a new community of effort alive in the lumber industry, sparked in large part by the growing conviction that we are not a dying and decaying industry but a vital and vigorous giant learning to flex our muscles. For many years, we were independent in the extreme; islands of self-satisfaction in a sea of prospective customers who needed us more than we needed them.

But today we are a striking force, welded together by the common

enemy of competitive materials, modern marketing techniques, and changing consumer needs. We are beginning to rise on the crest of a wave of consumer acceptance which may well carry us farther up the shore of prosperity than we have ever been before. Those of us who have learned our lessons well, who have learned to prepare ourselves to ride with this wave, will make it to the golden sands; those who have neither the vitality nor the confidence nor the desire will be tumbled off and disappear forever.

We have taken the first steps toward emerging as a case history in the reversal of a trend; a case history which, I might add, is causing the competition to burn the midnight oil to figure out new ways to stop us from winning back the markets we had lost and prevent us from staking claims to markets they haven't even thought of yet.

It is never easy to reconstitute any system. It is never easy to screw up your courage and let go of a steady raft to take a chance on a high-powered speed boat—things worth doing are seldom easy.

Additional Promotion

There are some who question whether we are warranted in undertaking additional expenditures for promotion on the heels of what proved to be a bad economic year for the lumber industry. I have told them the competition was hurt worse than we were and then I relate this story which seems most appropriate.

When Babe Ruth was at his peak, you will recall, his salary negotiations with Colonel Jake Ruppert were front-page news. In 1930, when the Babe asked for $80,000, Colonel Ruppert pointed out that was more salary than President Hoover received. The Babe grinned that famous grin and said, "I know, but I had a better year than Hoover."

We had a better year than other building materials both in shipments and in promotion. We think that we deserve to give our product better support on the strength of it. Did you notice that I said nothing about profits?

Last year in the face of a declining housing market, which was down about 18 percent from the previous year, lumber shipments were off only 8 percent. Aluminum, window glass, and brick, on the other hand, were off in greater degree. Total lumber consumption in 1960 ran ahead of 1957–58.

Of course, our program is young. We cannot definitely say that in so short a period we have reversed a trend. But I believe you will agree that this is a pretty sturdy straw in the wind.

Are each of the functioning parts of our industry, from the forest to the complete home, making the necessary changes to hold and improve markets? We must be partners in a dynamic effort to shape the future in the light construction field, the furniture market, the wood-using industries, and by-products field, so that wood will hold its enviable place in the shelter, the comfort, the need and satisfaction of American family life.

We want your suggestions, your criticism, your guide-lines, your participation. No group is better qualified to help shape this program in the realistic way it must go for that final dollars-in-the-pocket proof that is the rightful aim of all business enterprise.

The Marketing of Lumber and Forest Products to the Government[1]

A. M. CAMARANO
National Lumber Manufacturers Association

THE UNITED STATES GOVERNMENT is the world's largest buyer of goods and services. It exercises a great deal of influence on lumber markets and indications are that this influence will be sharply accelerated in the months and years ahead. The Federal Government spent more than a billion dollars on military construction alone last year and another 15 billion dollars to construct office buildings, post offices, research centers, schools, hospitals and the interstate highway system. All of these represent direct cash outlays and therefore have a direct relationship to lumber markets. But the government influences lumber markets to a much greater extent indirectly and in ways that often times go unnoticed. This influence is applied through government loans, grants and mortgage insurance programs as in the case of the College Housing Loan Program, the Urban Renewal Program, and the Federal Housing Administration and Veterans Administration Mortgage Insurance Programs. The government influenced directly and indirectly all phases of new construction activity which totaled 55 billion dollars last year.

The size and scope of government aid and assistance programs are tremendous and they will greatly affect lumber markets, affording many opportunities to those interested in the marketing of lumber and forest products. To participate in these programs, suppliers must understand some basic concepts about how the government does business. They must know how to seek out business opportunities. They must acquaint themselves with the programs offering the biggest opportunities for participation now and in the months ahead.

How the Government Buys:

Federal purchasing or procurement offices buy supplies and services in two ways: by "formal advertising for bids" and by "negotiation."

Advertising for Bids: When making a purchase by advertising for bids, a purchasing office sends invitations for bids to businesses listed on its bidders' list for the particular item. This list is made up of business concerns, construction contractors, or other appropriate concerns who have indicated a desire to bid on purchases of a par-

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 8, Division 11 (Marketing), June 21, 1961.

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Total Government influence on construction conservatively approximates some 50 billions of dollars. The size and scope of various governmental programs are tremendous, affecting lumber markets and offering possibilities to those interested in the marketing of lumber and forest products to the Government. Since suppliers and manufacturers must know how to seek these business opportunities, the author calls attention here to how the Government buys, who does the buying, and which Government programs offer the most opportunity.

ticular item. Government invitation for bids includes a copy of the specifications for the needed item, describing in detail the quality and other requirements of the supplies. It also includes instructions for the preparation of bids, and will state the conditions of purchase, delivery, and payment.

Bids are submitted on a proposed purchase and are opened in the procurement office at a time designated in the invitation for bids. The contract subsequently is awarded to the bidder who is deemed competent to carry out the contract and whose bid is considered the most advantageous to the government, in terms of price and other factors.

Buying by Negotiation: Under certain circumstances prescribed by law, government purchases may be made by negotiation with qualified suppliers, and without formal advertising for bids. In purchasing by negotiation, the procurement office asks selected suppliers for price quotations or proposals, including detailed analysis of estimated costs or other evidence of reasonable prices. These "Requests for Proposals" are sent to a number of suppliers so that the purchase will be made on a competitive basis, and to the best advantage of the government.

Locating Sales Opportunities

It is apparent that bidders lists of suppliers generally are the basis for government purchases, whether made by advertising for bids or by negotiation. Obviously then, those interested in selling to the government should seek to have their firm names placed on these lists. The following are three approaches an organization can take to gain placement on bidders lists in order to sell lumber directly to government agencies.

Major Military Lumber Purchasing Offices: Military consumption represents the biggest total of direct purchase of lumber and forest products by the government. Most of this lumber is bought by three agencies. Each maintains lists and announces impending lumber purchases. They are: District Engineer, U. S. Army Engineer District, 420 Locust Street, St. Louis 2, Missouri; District Engineer, U. S. Army Engineer District, 628 Pittock Block, Southwest 10th Avenue and Washington Street, Portland 5, Oregon, Attention: Chief Lumber Branch; District Engineer, U. S. Army Engineer District, P. O. Box 1889, 536 Old Post Office Building, Atlanta, Georgia, Attention: Chief Lumber Branch. These three offices purchased approximately 300,000,000 board feet of lumber last year at open auction for use by military establishments around the country.

Major Federal Civilian Purchasing Offices: The General Services Administration acts as the principal purchasing agent for many items including lumber and forest products used by civilian Federal agencies. Information as to the type and kinds of forest products purchased can be obtained by writing any of the following General Services Administration regional offices actually engaged in buying lumber and forest products.

Region 1
620 Post Office and Courthouse
Boston 9, Massachusetts
Area served: Maine, New Hampshire, Vermont, Rhode Island, Massachusetts, Connecticut.

Region 2
250 Hudson Street
New York 15, N. Y.
Area served: New York, Delaware, New Jersey, Pennsylvania.

Region 3
7th and D Streets, S. W.
Washington 25, D. C.
Area served: District of Columbia, Maryland, Virginia, West Virginia.

Region 4
Peachtree—7th Building
57th Street, N. E.
Atlanta 23, Georgia
Area served: Alabama, Florida, Georgia, North Carolina, Mississippi, South Carolina, Tennessee, Puerto Rico, Virgin Islands.

Region 5
U. S. Courthouse
219 South Clark Street
Chicago 4, Illinois
Area served: Illinois, Indiana, Kentucky, Michigan, Ohio, Wisconsin.

Region 6
GSA Building
2306 East Bannister Road
Kansas City 15, Missouri
Area served: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota.

Region 7
1114 Commerce Street
Dallas 2, Texas
Area served: Arkansas, Louisiana, Oklahoma, Texas.

Region 8
Denver Federal Center
Building 41
Denver 2, Colorado
Area served: Colorado, New Mexico, Utah, Wyoming.

Region 9
4th Floor, 49 Fourth Street
San Francisco, California
Area served: Arizona, Nevada, California.

Region 10
Federal Office Building
909 First Avenue
Seattle 4, Washington
Area served: Idaho, Montana, Oregon, Washington.

Synopsis of the U. S. Government Proposed Procurement, Sales and Contract Awards: The Department of Commerce, in cooperation with the government purchasing agencies, publishes a synopsis of proposed U. S. Government sales and contract awards. The publication is divided into three parts.

Part 1 summarizes certain purchases large enough to be of more than local interest to be made by the Department of Defense and various Federal civilian agencies.

Part 2 provides information on proposed sales of government surplus property both real and personal.

Part 3 lists contract awards by the Department of Defense, GSA and other government agencies. Through this awards listing suppliers can obtain "leads" to prime contractors who may need subcontractors with his firm's qualification.

The Author: A. M. Camarano is Manager of the Government Specifications Department for the National Lumber Manufacturers Assn., and a graduate of the Michigan State University School of Forestry. His job now involves working with Government agencies concerning their requirements for lumber.

. . . "greatest opportunities for marketing lumber are in government programs for housing . . ."

Getting Listed on Bidders Lists

After learning which agencies buy the items he can supply, a supplier should ask the agencies to send him the necessary forms to have his business listed on their bidders lists. In addition to the request for listing, the purchasing agency will send the business a form to fill out. The purchasing agency may also send a list of the products and services it buys, so that the concern can indicate those products it wishes to supply. However, if the purchasing office does not send a list of items, attach to the completed form a separate sheet showing:

a) the specific name of each product or service your company produces.
b) if applying for a listing on a military agency bidders list, any defense items or services your company has supplied in the past.
c) additional items or services your company could provide the purchasing agency. Suppliers should describe each product or service listed on this attached sheet and, if possible, should give the number of the government specification it meets or can be made to meet.

Government Specifications: Through the years, the Federal Government has prepared specifications for most of the products and services which it buys repeatedly. These specifications are in the form of written descriptions, drawings, prints, commercial designations, industry standards, and other descriptive references. Government specifications are divided into two principal groups:

Federal Specifications: Federal specifications cover the items and services purchased by civilian agencies. One or two copies of most Federal specifications are available upon request from the General Services Administration regional business service offices.

Military Specifications: Military specifications are used by the Department of Defense and apply to materials, products, or services used by the Armed Services. Requests for copies of military specifications should be directed to the custodian of the specification.

The use of government specifications by prospective bidders will help eliminate confusion and assist the bidder to supply the quality and type of lumber desired. They should therefore be used by all those interested in doing business with government agencies.

Other Programs

The discussion thus far has dealt primarily with opportunities for lumber and wood products suppliers involving direct procurement by government agencies and contractors. However, there exist today government programs which offer a greater potential to those interested in selling lumber. I would like to briefly outline a few of these programs and indicate their size and scope.

In a recent evaluation of the building industry outlook for the 1960's, the F. W. Dodge Corporation indicated that new construction during this decade will provide a market for more than 650 billion dollars in goods and services of which approximately 270 billion dollars, or roughly 40 percent of the new construction, will be provided by residential housing. Since the future of the lumber industry will be influenced to a large extent by the growth and stability of the housing market, the greatest opportunities for the marketing of lumber are to be found in those government programs related to housing and residential construction. Here, then, are a few programs worthy of consideration by lumber manufacturers and suppliers.

The College Housing Program: The college housing program is now in the tenth year of its existence. It was enacted into law as Title IV of the Housing Act of 1950. It is a direct Federal loan program which provides funds at low interest rates to assist colleges, universities, and teaching hospitals in the financing of housing facilities and related facilities for students and faculty where such assistance is not otherwise available. Loans are made for the construction of residence halls, married student and faculty housing, and for service facilities such as dining halls, cafeterias, college unions and centers, and in- and out-patient health facilities, as well as for rehabilitation, alteration, conversion or improvement of existing structures to make them available for such purposes. The College Housing Loan Program was broadened in 1957 to include housing for student nurses in hospital schools of nursing and housing for interns.

During 1960, college enrollments continued to mount. Tabulations of the Office of Education indicate that college fall enrollments increased from 3,402,000 in 1959 to 3,610,000 in 1960. According to conservative estimates, this figure will continue to increase to more than 6,000,000 in 1970. Although not all of these students will require housing, a substantial number must be accommodated if maximum use is to be made of the nation's colleges and universities. It appears logical that the College Housing Loan Program will be accelerated in the years ahead.

Since the inception of the program, a total of 2,248 applications for loans from colleges and universities, amounting to $2,271,000,000, have been received. Of these, 1,193 applications for $1,155,000,000 have been fully approved, 304 in the amount of $363,000,000 had reservation of funds and 114 in the amount of $150,000,000 were pending. This represents a grand total in excess of a billion and a half dollars which will have been spent under the College Housing Loan Program. As will be shown later, most of this construction is of a type which can or is already utilizing lumber and wood products of various types.

Following approval of a college housing loan, a university enters into a loan agreement with the borrowing institution under which the government agrees to purchase the bonds to be issued for the project at a specified rate of interest, providing that no other equal or more favorable bids are received when the bonds are offered for public sale. Portions of the bond issue may be bid against, affording an opportunity for private investors to purchase the earlier maturities. However, with the current rate on college housing loans around 3½ percent which is substantially below the market rate on comparable securities, there was little of this type participation during 1960.

As of December 31, 1960, construction of 871 projects with housing accommodations for 209,283 students and faculty had been substantially completed and another 211 projects with housing accommodations for 43,286 students and faculty were under construction. There were also 111 projects in the approved category where construction had not been initiated as of December 31, 1960. These latter projects will house 29,228 students and faculty.

The College Housing Loan Program is administered by the Community Facilities Administration of

the Housing and Home Finance Agency. However, plans and specifications concerning the type of construction and the materials to be used are developed by the colleges and universities, and they can give clear insight to those suppliers interested in this type program.

Federal Housing Administration Home Improvement Program: For 26 years, the Federal Housing Administration (FHA) has been insuring home improvement loans and more than 23 million homes have been improved under this program. This is approximately 46 percent of the estimated 50 million homes in the United States today. The money borrowed for property improvements is advanced by local lending institutions. It is not a government loan. FHA does not loan the money, it simply insures the loans to make the money easily obtainable for home improvements. FHA insured property loans are used to pay for the alteration, repair, improvement or conversion of existing homes and other structures and for the building of new nonresidential structures such as garages. To qualify for a FHA insured property improvement loan, a person must own the property he wishes to improve. He must also have a good credit record and a regular income that will enable him to make the payments on the loan without undue hardship. FHA loan insurance protects the lender against loss. It does not insure the borrower against loss, although it benefits him in many ways, namely; no down payment is required; no collateral or security is necessary; FHA limits the interest rate to a maximum of 5 percent discount on this type of loan and lending institutions give prompt service on FHA insured loan applications.

There are four different types of FHA insured property improvement loans. Two are concerned with improvement to existing buildings, and the other two with the building of new structures:

Repairs and Improvements: Class 1 (a) loans are made for alterations, repairs and improvements to homes and other properties. The building to be improved must be a completed structure—this applies to both homes and nonresidential structures. A residential or nonresidential loan may be made in any amount up to $3,500 and may run as long as 5 years.

Multi-Family Homes: Class 1 (b) loans are made for altering, repairing, improving or converting existing structures used, or to be used, as apartment houses or dwellings for two or more families. A loan of this type can be used to convert a single-family home or a building into apartments, or to modernize and alter apartment buildings.

The amount of the loan is limited to $2,500 for each dwelling unit in the existing structure, but not more than $15,000 altogether. It may be repaid in installments over a period up to 7 years.

New Commercial Structures: Class 2 (a) loans are made to finance the building of new structures to be used exclusively for purposes other than residential or agricultural. A warehouse, a filing station, or a retail store is an example of such a building. Loans of this type are made in amounts up to $3,500 and are repaid in monthly installments over periods up to 5 years.

Farm Property: Class 2 (b) loans are used to pay for building new service structures on farms, such as barns, silos, smokehouses, granaries, and others.

More than a million loans amounting to $982 million were made by FHA last year under the Home Improvement Program.

Last year, 1,011,858 loans amounting to $982,405,000 were made by FHA under the Home Improvement Program. Approximately 30 percent of the proceeds were spent on additions and alterations; 17 percent on exterior finish materials; 11 percent on interior finish materials; and 5 percent on the construction of new nonresidential construction. More than 60 percent ($600,000,000) was spent on home improvements where lumber is normally used as the prime building material. Indications are that FHA will become more active in granting insurance on home improvement loans and that the country will become more improvement conscious in the months and years ahead. Since this is a local program, lumber sales will be generated for local lumber suppliers and dealers in relationship to the amount of home improvement work being generated in their respective areas.

Urban Renewal Program: The Urban Renewal Program was initiated by the Housing Act of 1949. The purpose of this program is to provide Federal aid for projects involving the grants of slums and lighted areas initiated by local agencies which contribute to the development and redevelopment of stable communities. Since its inception, the Federal government has been authorized to make available, through loans and grants, $2,000,000,000 to municipalities with sound programs of community rehabilitation and slum clearance. As of December 31, 1960, a total of $1,866,160,059 had been awarded for the construction of 870 urban renewal programs in 500 communities.

Local Responsibilities: In entering into any contract for advances for surveys, plans and other preliminary work for projects, consideration is first given by the Federal government to the extent to which the appropriate municipalities have undertaken positive programs which will prevent the spread or recurrence of community slums. No contract can be entered into for any loan or grant unless a municipality has developed a specific program for effectively dealing with the problem of urban slums and blight within the community and for the establishment and preservation of a well-planned community.

Urban renewal programs may include the following:

1) Acquisition of: a) a slum area or a deteriorated or deteriorating area; or b) land which is predominantly open and which because of obsolete or deterioration of structures or sight improvement impairs the sound growth of the community; or c) open land necessary for sound community growth which is to be developed for predominately residential uses.

2) Demolition and removal of buildings and improvements.

3) Installation, construction or reconstruction of streets, utilities, parks, playgrounds, and other improvements necessary for carrying out the urban renewal plan.

4) Disposition of any property acquired in the urban renewal area (including sale, initial leasing or retention by the local public agency itself) at its fair value for uses in accordance with the urban renewal plan.

5) Carrying out plans for a program of voluntary repair and rehabilitation of buildings or other improvements in accordance with the urban renewal plan.

STATUS OF TITLE VIII (CAPEHART) HOUSING PROGRAM
AS OF MARCH 31, 1961

Installation	Total Units*	Housing Units			
		Completed	Under Construction	Bidder Accepted	In Process*
Army	36,385	24,280	7,548	723	3,834
Navy	19,806	9,135	6,244	-----	4,427
Air Force	59,950	46,732	9,733	1,430	2,055
	116,141	80,147	23,525	2,153	10,316

*Includes approximately 5,300 units which will not be built because of the last proviso of Section 803(a) of the National Housing Act as amended.

6) Acquisition of any other real property in the urban renewal area where necessary to eliminate unhealthful, unsanitary or unsafe conditions.

Of 522 urban renewal projects surveyed last year, approximately 270,496 original dwelling units were involved, of which 214,702 were substandard and in need of replacement and the remainder had to be repaired and modernized. The construction and rehabilitation of these units was of a type in which lumber and wood products played a prominent part. Indications in Washington are that the Congress will authorize the expenditure of another 2½ billion dollars for urban renewal programs over the next 5 years. If this is true, then the opportunities for lumber suppliers under this program will indeed be great, at least for those individuals who are diligent in pursuing urban renewal projects in their areas.

Capehart Housing Program: Few government programs have been more controversial than the Capehart Housing Program which was instituted some 5 years ago to provide military personnel and their families with houses commensurate with those owned by the civilian populace in the areas which they were serving. However, this program has been most beneficial to the lumber industry. According to recent Department of Defense statistics, approximately 80,147 Capehart units have been built at military establishments located throughout the country. Most of these units were wood frame with either wood siding, brick veneer, or a combination of both. They contained appreciable quantities of lumber for windows, doors, siding, sub-flooring, interior trim, paneling, wall and roof sheathing, roof trusses, framing members, and the like. The program has been especially beneficial to the lumber industry because it was nationwide and afforded many suppliers an opportunity to participate in Army, Navy, Air Force, and Marine Corps bases in all States. While it is true that most of the construction contemplated under this program has been completed, there are still a number of projects to be constructed as well as a good number already in construction which will be of particular interest to those suppliers located in the States where construction is underway or contemplated. The latest status report on the Title VIII Capehart Housing Program is shown by the table.

When I left Washington, there was still considerable doubt as to whether or not the Capehart Program would be continued. It is my own belief that a limited number of Capehart Housing units will be authorized for construction during the fiscal year of 1962, which begins on July 1st. However, even if the program is discontinued, there still are a good number of units to be constructed with money which was appropriated last year. Information on these and other military construction projects can be obtained from Army District Engineer Offices; Navy Public Works Offices; Air Force Command Headquarters and at local military installations.

Federal Highway Program: The construction of the interstate highway system administered by the Bureau of Public Roads in Washington, represents one of the biggest continuing government programs being carried on today. Oftentimes this program is ignored by lumber suppliers because it is not generally associated with the consumption of lumber and wood products. However, appreciable quantities of lumber and wood products are used for form lumber, sign posts, signs, guard rails, bridge timbers, shoring materials, piling, and a myriad of other uses. The Bureau of Public Roads estimates that an average of 72,000 board feet of lumber and 4,000 lineal feet of piling is used for each million dollars spent on the construction of the interstate highway system. During the calendar year of 1960, a total of 7,098 Federal-aid highway and bridge construction contracts was awarded by the State Highway Departments involving a total cost of 3.1 billion. This represents a dollar volume increase of almost 25 percent over the comparable 1959 figure of 2½ billion spent by the Federal government. Using the figures furnished by the Bureau of Public Roads, approximately 2,242,000 board feet of lumber and 124,000 lineal feet of piling was used in the construction of the Federal-aid highway program alone. Since this is a 10-year program which is expected to increase modestly annually, it represents a market potential for lumber and wood products which deserves more than casual consideration. There also exists a similar potential of almost equal magnitude in highway construction programs being carried on by State Highway Departments with funds appropriated solely by the States. Here the prospect for lumber consumption is even brighter because the use of lumber and wood products is greater when secondary roads are constructed. Since State Highway Departments decide the materials to be used and specified for their own highway programs and the interstate highway system, they can provide interested suppliers with an accurate picture regarding the use of lumber in their respective States. Suppliers interested in selling products normally used in the construction of highways and allied facilities should become acquainted with the requirements of the State Highway Departments in their States.

Time does not permit us to cover a number of other government programs which hold good promise for lumber suppliers. The Public Housing Program, Housing for the Elderly, the Nursing Home Program are but a few.

The prospects for the marketing of lumber and wood products to the government are indeed many and varied for those willing to expend the time and effort to search out these opportunities and vigorously pursue them.

. . . prospects are many and varied for those willing to expend time and effort to pursue them . . .

Particleboard—

today and tomorrow[1]

ROBERT E. DOUGHERTY
National Particleboard Association

What is the status of particleboard today? And where is it going tomorrow? Here, the author presents a comprehensive narrative review of the situation.

PARTICLEBOARD HAS ONLY BEEN produced commercially in the United States since the late 1940's and very early 1950's. It is still in its infancy but the child is robust. The faith of the industry's companies such as Swain Industries and the United States Plywood Corporation account for this in great part.

Particleboard came to this country from Europe, the Germans being the leaders in its development. The Swiss and the English also were active in the field. In Europe it was born of necessity dictated by limited amounts of wood as a raw material. The wood-hungry European forest products industries have long emulated the great American meat packing companies in extracting "everything from the pig but the squeal." This is evidenced by their intensive controlled forest management. Much of the raw material for particleboard, particularly in Germany, comes from forest thinnings. The basis for the need of particleboard in Germany was furniture corestock as it was to a lesser extent in Switzerland. The Swiss were also interested in construction and decorative applications of particleboard.

In the United States the motivation that gave impetus to the development of the industry was waste utilization. The growing efficiency of debarking machinery and its increased use made the utilization of slabs and edgings more and more a necessity. Even the burgeoning American paper and pulp industry failed to take up the available supplies of wood. Long since, the great hydro-electric installations around the nation had greatly replaced the burning of waste wood for steam or electric power in the wood industries. As the forest products industries looked around a little further in the search for fuller utilization, planermill shavings came into the picture. Furniture companies were seeking uses for their cuttings. In fact, almost any kind of mill-ends were studied for utilization value.

Diversification

The relatively recent trend in American business to diversify had its effects on the coming of age of particleboard. In an effort to diversify its product line, as well as utilize waste materials, many American companies went into the manufacture of particleboard.

In this same trend toward diversification there developed another facet in the waste utilization picture. Particleboard plants were built in areas in the country where, it was determined, after proper economic surveys, that they could derive their raw material from the waste products of other wood products producers located in the area. One such example of this is utilization of waste from box plants.

And finally the industry took the ultimate step and began producing particleboard from roundwood. Even this had its utilization and conservation features because it not only made use of the thinnings from properly managed forest lands but certain species of trees formerly regarded as weed trees now found their way into the manufacture of the new board products.

Present Status

So much for history. Where is particleboard today? Today the industry is rapidly changing from the state of mind that marked the thinking of its pioneers. As one industry spokesman put it, "since the beginning of particleboard development in the United States, the marketing problems have not been well understood. Most of the pioneers had in mind the production of an all-purpose board. The board was known to be suitable for door and furniture corestock but it was more often thought of as a material that could be used for wall paneling, sub-flooring, sheathing and many other purposes. Until recently the industry did not concentrate on markets most easy to invade. It diluted its efforts in an attempt to be all things to all men." (Carl A. Rishell, Vice President, Timber Engineering Company, *Industrial Woodworking*, February 1958.)

We are departing from the concept of being all things to all people. Presently the industry is thinking not of a single board that will do everything

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[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 7, Division 5 (Particle and Fiber Processes B), June 21, 1961.

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but rather of a series of types of board aimed at specific end uses. All of these boards will be known by the generic term of wood particleboard, because the basic system of manufacturing employed will be the same. But you find more and more in the industry a tendency to call its products by names which describe them by type and thus identify them as to end-use. Thus, particleboard producers engaged in the production of particleboard for floor underlayment so designated it or in some cases will identify the product as a shavings-type board which lends itself very well to that end-use. Boards for corestock of various kinds will show in their labels and advertising that they are homogenous flake or three layer flake faced boards. In short, the industry is no longer just manufacturing a flat board product made up of chips, splinters, flakes, shavings, or whatever, put together by process similar to that for plywood. Today particle board is an engineered material. Much attention is paid by producers to the physical condition and properties of the wood used; its species; moisture; and most importantly the configuration of the particle itself. Much research and development has gone into the study of how to produce the right particle configuration for a desired type of board.

As evidence, also, of this trend to make uniform the industry's end products is the great amount of effort made to develop proper standards. The Technical Committee of the newly formed National Particleboard Association devotes the majority of its time to the formulation and establishment of standards for various uses of particleboard. The West Coast Particleboard Association does likewise.

Uses

What does all this mean in terms of the uses into which particleboard goes today? The realization by the industry that our products must be engineered for their end-uses is a prominent factor in two large general areas.

First is the construction field. There are literally millions of square feet of installed particleboard in housing projects throughout the country in use as underlayment under resilient flooring. Principally this is in the kitchen area in residential construction. We are engaged in a close and continuous liaison with the resilient floor manufacturing industry. It is our mutual aim to develop a superior floor system. Further, there are particleboards presently in use as floor tile per se. There is particleboard being used as exterior siding and for sliding closet doors.

In construction of various kinds, particleboard is often present but not seen. These are the hidden uses. In housing it may find its way into doors as corestock or into kitchen cabinets and certain built-in fixtures. It is commonly the corestock under high-pressurel laminants in sink tops. In business construction it finds its way into counter tops, shelving, and store fixtures, such as the so-called gondola-type display rack. It is being used as corestock for decorative hardwood paneling for use in both home and business construction.

AUTHOR DOUGHERTY, Executive Director, National Particle Board Association, "welcomes tomorrow for the future of particle board."

The second large use area is really the one for which particleboard was originally created in Germany back in the 1940's. This is corestock in furniture. In the furniture area, there are several divisions. The manufacturers of fine living room, dining room and bedroom furniture are using particle board corestock. The so-called "dinette" furniture manufacturing trade also utilizes it. It is to be found in wood office furniture and finally a relatively new use, as corestock in motel furniture. This latter application is quite important. The motel industry has expanded spectacularly in the United States in the last decade. It has meant a market for furniture that never existed before and it demands in its furniture, an article of rugged construction that is not only handsome to look at but can "take it." Particleboard has demonstrated that it can.

Particleboard also has its miscellaneous end-uses to which go a relatively low percentage of the industry's products. It has been used in the construction of children's furniture, and in the manufacture of school furniture and toys. It is being used in the center part of ski blanks where they are built up to take the weight of the skier. In this case the particleboard is faced with a ¼-inch durable plastic material.

Statistics on particleboard end-uses are virtually nonexistent. The compilation of these statistics is one of the tasks the industry recognizes it must undertake. The National Particleboard Association has such a statistical program under way.

A very preliminary and limited survey made in 1959 of but five particleboard producers, a total of 6 plants, disclosed the following as to percentage end-uses:

End-Uses	Number of Companies	Average percentage of production going into end-use
Furniture, wood	6	29
Furniture, dinette	3	26
Cabinets, kitchen	4	18
Doors	1	14
Sink tops	4	15
Store fixtures	5	11
Floor underlayment	5	29
Toys and games	3	4
Miscellaneous	5	6

These figures are of little significance except to show the areas of end-use. As of today, however, the principal uses shown in the survey, i.e. furniture, dinette, and cabinet corestock, appear to continue to be foremost. Floor underlayment is in the ascendency.

Future Uses

What of particleboard in the future? There is much truth in the old cliche that "there's nothing new under the sun." A review of the history of the industry illustrates that almost any new or novel use that one can dream up for particleboard has either been attempted or at least thought of. On the northern exposure of the National Archives Building in Washington, D. C., are two large figures. One says, "What is past is prologue" and the other says, "Study the past." This is what our industry is doing today. We envision a great variety of new and different particleboard products. This is already being done. Wood chips used in conjunction with chopped glass fiber and polyester resin is today going into the manufacture of school furniture and parts for upholstered furniture such as sofa wings. Where today producers rout out particleboard panels and affix to them curved wood surfaces, some day they will mold all this. With the advances being made in the development of resins we see particleboard being used more and more in the construction industry in such areas as roof decking, partitions, and siding.

One of the West Coast producers has built an experimental house of

particleboard. The exterior siding, the roofing, the sheathing are all exterior-type board. The subflooring and underlayment throughout the entire house is particleboard. Every door except the front entrance is particleboard as is the garage door. All the interior partitions as well, some of them are routed to resemble random-width planking. In the kitchen all working surfaces and all the cabinets have particleboard corestock. And to cap the climax one room has a particleboard ceiling manufactured to a pattern similar to acoustical tile.

Today's three layer boards may well be replaced by five or even seven layer boards. Already in Germany particleboard has been used for bulkheads in scipbuilding, and has been further exposed to such exterior uses as tool houses, poultry houses, and other farm buildings.

In the United States we see a possible growing market in the interiors and floors of house trailers.

Another new use—one company has already pioneered a newly designed end-wall for freight cars which will withstand the tremendous force exerted against the forward and after ends of freight cars loaded with barrels. This product is a 5-ply board with a mat-formed wood particleboard core ⅜ inch thick, 1/16 inch crossbanding, and about 1/32 inch face veneers. The face veneers and crossbanding are ash or hickory.

There are, at least in the experimental stage, coated boards for laboratory and industrial tables which will withstand impact and acids. Blackboards are being made of slate-painted particleboard.

Fire retarding and fireproofing are continually under study, as are insect and fungus preventives.

The Hammond Organ Co. has investigated various types of particleboard for possible use as core and panel stock in organ cabinets. Besides panel-stock, particleboard was successfully tested for use as baffle boards in the interior of the instruments. Among the conclusions drawn by Hammond was that they "consider particleboard as a material having its own characteristics and not as a substitute for something else." They go on to report that, in their opinion, there is no doubt that "particleboard, whether flake, particle or multi-layer type, has a definite place as a cabinet material." So, another possible end-use for particleboard appears upon the horizon for further development. In fact, let one's imagination run rampant and it would likely cover the thinking in the industry's laboratories.

Conclusion

This is where the particleboard industry is today and where we are going tomorrow. Perhaps the most salient factor is the industry's departure from the concept of an "all-purpose" product. Today the thinking is to develop types of boards tailored to the end-uses demanded today. But it doesn't end there—the industry is oriented toward the future applications of our engineered products.

If one could pinpoint a single characteristic common to the men of our industry, it is the feeling of confidence in our products and a belief in our future. We look forward to and welcome tomorrow!

Costs... a key to sawmill profits[1]

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THE BUSINESS ENVIRONMENT of the last decade was fast moving and highly competitive. During this era many successful wood products firms were managed by "seat of the pants" methods. Decisions were made on hunches or a "feel" for the situation. Will this type of management lead to success during the sixties?

Naturally, only time can answer this question. However, it seems inadvisable to play hunches when today there are many managers' "tools" available. One of these is process cost accounting which gives a manager the factual cost information necessary to make correct decisions.

Although cost accounting is not new, why then do only a small minority of wood processing firms use such an effective method of determining their costs? Possible reasons for this are the characteristically small independent firms which make up the industry. Eighty-three percent of all the lumber and wood processing plants in the United States are small and employ less than 20 persons. If the size criterion is increased to 100 employees, 95 percent of the nation's wood products firms would be included. This vast majority of comparatively small enterprises employs about 57 percent of the industry work force and produces approximately half of the industry's output.[2] Laxity and indifference in compiling and using accurate cost data appears to be a common characteristic of many small organizations. A common remark is: "We are so small we can afford only to keep the records required by law."

Perhaps it is not unreasonable to assume that the management decisions of this large wood industry segment greatly affects the business environment in which the fewer more deliberately managed firms must function.

Figure 1[3] serves to illustrate how uninformed, "snap" decisions can adversely affect normal business economics. The question evolving from the comparative indexes shown is: have increased wood residue recovery operations influenced the increases in stumpage prices for southeastern lumber manufacturers? The rapid growth

"What are the costs?" Invariably, this is the first question confronting the management of any enterprise. To answer it, management must properly assemble and use cost information. Too often processors of forest products neglect or misuse an accurate, versatile management tool—process cost accounting.

of chipping sawmill wastes for pulping purposes brought opportunities for increased profits. One of the very first reactions in many firms was to turn much of this profit back into increased payment for logs and standing timber. This happened during a period when the lumber market was characterized by a stable or declining prices. Someone started it, and many more were forced to follow! Obviously, cost records associated with chip production and the attendant increased capital investments were either nonexistent, inaccurate, or completely disregarded. Today, many lumber men in that region admit to more cash flow, but little if any extra profit from chipping operations. Did the industry create its own Frankenstein simply because process cost accounting was misused or completely overlooked?

The record would seem to indicate that many firms have lost control of their business reins. Figure 2[4] illustrates the trend of business failures in the wood products industry. The demise of these enterprises has surely had an impact on the market and business conditions in which survivors must now operate. Similar to Mark Antony's eulogy on Caesar, "The evil that (these firms) do lives after them."

Thus, any firm and its many suppliers, customers, and competitors should have a vital interest in any system which helps improve the management decisions within the industry.

What is Process Cost Accounting

Process cost accounting involves the assembling of cost data by items, categories, types, and processes. It is flexible, and depending upon the size of the firm, the system may be designed to be as fine or as coarse as management judiciously deems necesary. In one firm a process may involve an entire department—for instance, a planing mill or dry kilns of a lumber plant. Another organization may consider the headsaw as a process even though that piece of equipment is physically part of an entire manufacturing unit.

What Process Cost Accounting Can Do

Process cost accounting is a management tool that may be compared to navigational aids. It enables the business manager to chart an operating course, and permits him to know:

1. Where he is: to currently determine the manufacturing cost position at any time.
2. Where he is going: it indicates the weak points of the manufacting process for corrective action.
3. Progress towards objectives: answers the question, "how quickly are goals being achieved?"

Types of Costs

An understanding of the types of total costs is essential to the development of a process cost accounting system. Basically these types are fixed and variable. Fixed costs are those which are in effect "locked" into the enterprise and continue to exist during the life of the business. All other manufacturing charges are variable and are a function of time and volume of production. Variable costs are usually further divided. It is important to realize how the various types of total costs function as the business is operated.

Fixed: If the amount of capital invested in the business is not altered, the total fixed costs remain constant regardless of the level of production. Examples of fixed costs are depreciation, property taxes, and insurance on property.

Variable Overhead: These total costs are not associated with the volume of production. They may vary from time to time, but are independent of the rate of production. Examples of variable overhead are salaries, clerical charges, and advertising.

Variable Operating: These charges are production associated in that they vary with changes in production levels. However, they do not necessarily vary in proportion to changes in the rate of production. Examples of variable operating are productive labor, power, and supplies.

Variable Direct: These costs are directly related to the level of production and vary in proportion to the rate of production. Examples of variable direct costs are raw material and labor on piece basis.

Total Costs

The usual basic business records can generally provide data necessary to the assembling of total costs. Variable costs may be extracted from such sources as payroll records and invoices for goods and services purchased during the accounting period. Fixed costs are obtainable from property tax assessments and payment records, certain insurance premiums, and depreciation schedules.

To be useful in management, costs must be assigned to the processes being considered. This involves a systematic indexing of the various incurred charges. A common practice is to use account numbers. Initially then, a listing of separate charges associated with the operation of the business must be compiled and identifying numbers assigned to the various items. These items may further be categorized into groups such as labor, operating supplies, fuel, log account, depreciation, insurance, and taxes.

The process cost accounting system breaks the charges down into four classifications. Consider for example, a process cost accounting system for an actual small permanent sawmill. The enterprise was divided into seven processes of which two are machines:

10. General sawmill	Sawmill
11. Yard (log deck)	
12. Circle headsaw	
13. Edger	
14. Stacker	
15. Logging operations	
30. Office	

As an example, the account for the inspection and grading of lumber could be written: 10.2013.

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 14, Division 3 (Mechanical Conversion), June 22, 1961.

[2] Statistics obtained from Bul. MC-203 Census of Manufacturers, Bureau of Census, Dept. of Commerce.

[3] Statistics obtained from "The Demand and Price Situation for Forest Products," Forest Service and Commodity Stabilization Service, U.S. Dept. of Agriculture, Nov. 60, Tables 4, 7, 8, and 11, and "1959 Pulpwood Production in the South," Todd, A. S., Jr. and Nichols, Agnes C., Forest Service U.S. Dept. of Agriculture, 1960.

[4] Wright, R. "Dun's Review and Modern Industry", June 1952–1959.

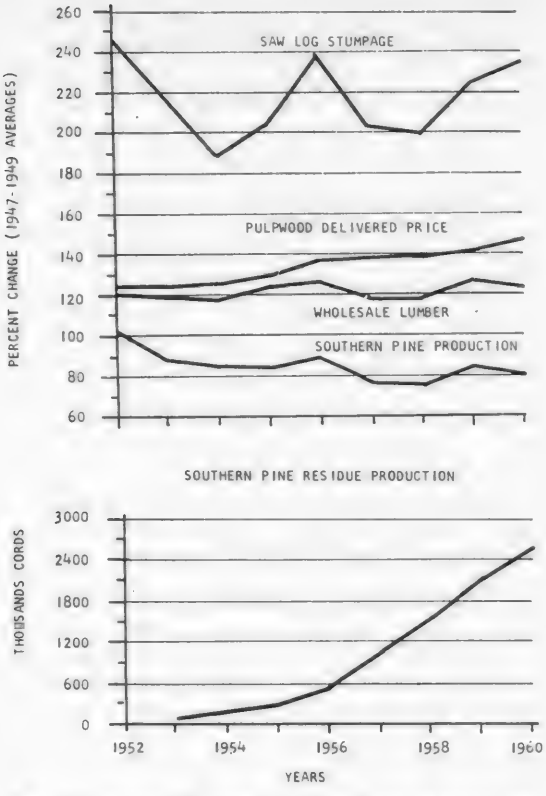

Fig. 1.—Comparative indexes and wood residue production in the southern pine region are shown.

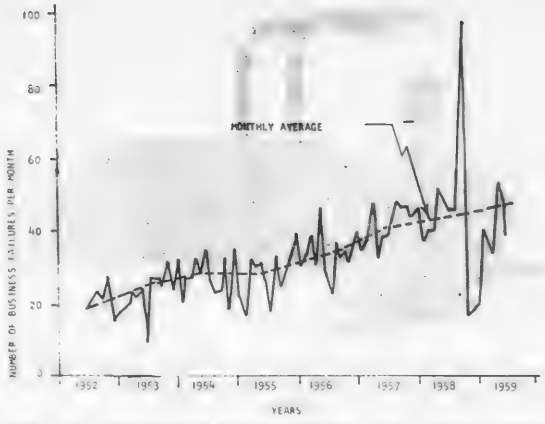

Fig. 2.—The trend of business failures in the wood products industry over a 7-year period is shown.

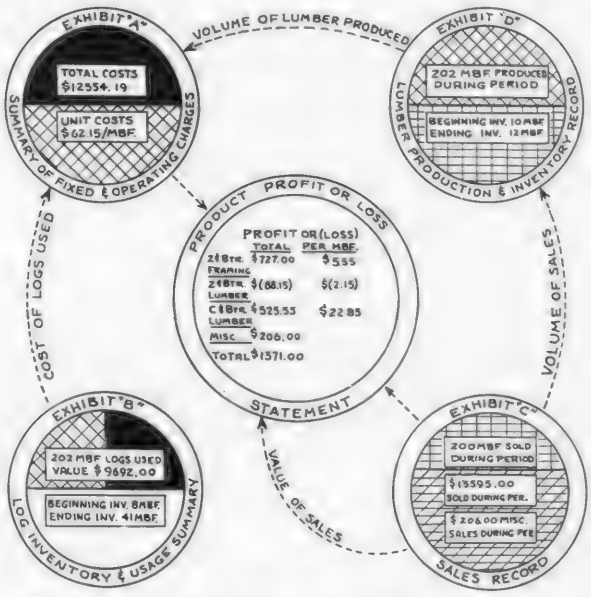
EXHIBIT "A"
TOTAL COSTS $12554.19
UNIT COSTS $62.15/MBF.
SUMMARY OF FIXED & OPERATING CHARGES
VOLUME OF LUMBER PRODUCED
EXHIBIT "D"
202 MBF PRODUCED DURING PERIOD
BEGINNING INV. 10 MBF ENDING INV. 12 MBF
LUMBER PRODUCTION & INVENTORY RECORD
PRODUCT PROFIT OR LOSS
PROFIT OR (LOSS)
TOTAL PER MBF.
2 & 3 Brd. FRAMING LUMBER $727.00 $5.55
2 & 3 Brd. LUMBER $(68.15) $(2.15)
C & Brd. LUMBER $525.53 $22.85
MISC. $206.00
TOTAL $1371.00
STATEMENT
COST OF LOGS USED
VOLUME OF SALES
EXHIBIT "B"
202 MBF LOGS USED VALUE $9692.00
BEGINNING INV. 8 MBF ENDING INV. 4 MBF
LOG INVENTORY & USAGE SUMMARY
VALUE OF SALES
EXHIBIT "C"
200 MBF SOLD DURING PERIOD
$13595.00 SOLD DURING PER.
$ 206.00 MISC. SALES DURING PER.
SALES RECORD

Fig. 3.—Shown is a graphic interpretation of the flow of costs.

10. Gen'l Sawmill (Process or dept.)	2 Variable Overhead (Type)
0 Labor (Category)	13 Inspection and Grading (Item)

For instance, the account for the purchase of rings and bits for the circle headsaw would be indexed:

12. Circle Headsaw (Process or dept.)	3 Variable Operating (Type)
1 Operating Supplies (Category)	01 Parts and Replacements (Item)

The versatility of this method of assigning charges is illustrated in its application to keeping maintenance records. The repairs to a headsaw involving the replacement of a faulty setworks would include the cost of new parts plus the labor. The process number 12 automatically keys the repair charges to the headsaw. In a larger organization, the second digit of the process or department number serves to identify a single piece of machinery out of the many machines which may be included in a department. Such information is valuable in analyzing problems involving the continued repair or replacement of capital equipment.

Assembling Data: For the small sawmill in this example, certain forms or exhibits, were developed. These are:

Exhibit A: A summary of fixed and variable charges, derived from the indexed accounts makes up Exhibit A.

Exhibit B: A log inventory and usage summary developed on a continued inventory basis makes up Exhibit B.

Exhibit C: Sales of lumber and by-products, developed from shipping records comprise Exhibit C.

Exhibit D: Lumber inventory and production record, also developed on a continuous inventory system is Exhibit D.

[5] Cost data presented are for example only and do not necessarily represent actual incurred costs.

Total Production Costs: Total production costs can be obtained through tabulation of all processing and raw material charges incurred during the period. Exhibit A[5] provides a listing of indexed accounts which can be tabulated as management deems necessary for proper controls. The example incorporates a 4-week accounting period of which there are 13 per year. Periodic fixed charges are computed by dividing annual fixed costs by thirteen. All variable costs are tabulated by accounts and then inserted beside the appropriate account listing. Total log costs on a lumber yield basis can be obtained from information contained in Exhibits B, C, and D. These latter exhibits are self-explanatory forms and for this reason the exact format of each has been omitted.

Unit Production Costs: Unit costs in this example are the costs incurred in the manufacture of 1,000 board feet of lumber. The unit costs item-

EXHIBIT A

1 Dept. Process	2 Item (Acct. #)		3 Cost This Period	4 Cost Last Period	5 Cost Yr. Date	6 Cost/ MBF This Period	7 Cost/ MBF Last Period	8 Cost/ MFB Yr. Date
	Depreciation	.1301	$ 12.49	$ 12.49	$ 74.94	.06	.06	.06
	Depreciation	.1302	18.37	18.37	110.22	.09	.08	.09
	Insurance	.1400						
10	Tax—Prop.	.1501	.23	.23	1.38			
Gen'l	Supervision	.2001	523.20	523.20	3,139.20	2.59	2.39	2.45
Sawmill	Inspection	.2013	218.04	224.19	1,314.14	1.08	1.02	1.03
	Day labor	.3003	87.00	96.29	559.45	.43	.44	.44
	Repairs	.3101	24.16	18.42	109.38	.12	.08	.09
	Supplies	.3102		5.16	18.84			
	Fuel oil	.3103	7.94	8.27	40.57	.04	.02	.03
	Gas and oil	.3104						
	Electricity	.3105	8.02	8.16	48.41	.04	.04	.04
Subtotal			899.45	914.78	5,416.53	4.45	4.17	4.24
	Depreciation	.1301	25.74	25.74	154.44	.14	.12	.12
	Insurance	.1400						
11	Tax—Prop.	.1501	.10	.10	.60			
Yard	Day labor	.3003	191.84	204.71	1,196.55	.95	.93	.93
	Repairs	.3101	10.08	8.43	50.59	.05	.03	.04
	Gas and oil	.3104	44.08	38.87	241.11	.22	.18	.19
Subtotal			271.84	277.85	1,643.29	1.35	1.26	1.28
	Depreciation	.1301	65.62	65.62	393.72	.32	.30	.31
	Insurance	.1400						
12	Tax—Property	.1501	.32	.32	1.92			
Circle	Day labor	.3003	523.20	523.20	3,170.92	2.59	2.39	2.48
Mill	Repairs	.3101	33.90	26.01	179.91	.17	.12	.14
	Supplies	.3102	70.88	31.19	214.07	.35	.14	.17
	Electricity	.3105	98.60	103.06	576.06	.49	.47	.45
Subtotal			792.52	749.40	4,536.60	3.92	3.42	3.55
13 Edger								
14 Stacker								
Total All Processing Costs			2,862.19	2,840.41	15,190.94	14.17	12.97	11.87
Cost of Logs			9,692.00	10,303.95	59,693.55	47.98	47.05	46.60
Total Mfg. Costs			$12,554.19	$13,144.36	$74,884.49	62.15	60.02	58.47

ized in Exhibit A are obtained by dividing total costs per item by the production in units for the period involved. Production data is derived from Exhibits C and D, and log costs are obtained from Exhibit B. A very valuable guide to the analysis and control of manufacturing costs will be achieved if total and unit cost summaries are arranged for historic comparisons.

In the examination of Exhibit A, it may be noted that item .3102 (supplies) in process 12 (headsaw) showed a marked increase in total costs over the preceding period. On a unit basis, this is reflected as exceeding a 100 percent increase for the item. Investigation revealed that during the sixth period, weather and sandy soil conditions at the logging site resulted in "gritty" logs. This required an extraordinary large replacement of saw bits during the operating period and an 8 percent production drop due to excessive filing time. Thus, processing costs were increased over the previous period and the average for the year to date. In this particular situation, it would have been profitable for the mill manager to hire extra labor to wash the logs.

Flow of Costs and P & L Statement: The relationship of the various exhibits to each other is illustrated in the "Flow of Costs Diagram," Figure 3. The information in the four exhibits is employed to develop the "Product Profit and Loss Statement." The Product P & L statement readily indicates which products are the most profitable to manufacture, which are the least profitable or which items show an actual loss of profit. However, this does not automatically imply "loss" products should be discontinued as such action could conceivably result in increased unit costs. The advisability of procuring raw materials on the basis of grades and yields and the allocation of various grades of logs to various products may also be made evident.

Summary

Often many problems of wood processing firms and particularly the many small concerns are attributable to the absence of accurate cost data. Where records are maintained they are often inadequate for management purposes. Process Cost Accounting offers a versatile method of assigning, indexing, and using cost data as a management guide. The technique is flexible to changes in plant and processing methods.

In addition to providing information concerning manufacturing costs and product profitability, it has further value in 1) planning and evaluation of equipment maintenance programs; 2) establishing equipment depreciation and replacement policies; 3) determining short run operating policies in depressed markets; and 4) making decisions involving alternate methods of production which may necessitate increasing plant capitalization.

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Appendix A.—ACCOUNT LISTING WITH THE ASSOCIATED TYPE COST

A. Labor	.0000
Oversight and clerical	.2001
Incentive labor	.4002
Day labor	.3003
Shift premium	.3004
Accident and lost time	.3005
Overtime premium	.3006
Truck, dumping and other misc.	.4007
Move and rearrange	.1008
Make and repair sawmill tools	.2009
Repair and maintenance	.2010
Repair and maintain grounds and yard	.2011
Watching and guard duty	.2012
Inspect gauge and test	.2013
Packing and shipping	.3014
Material handling	.3015
Preventive maintenance	.3016
Rigging (millwright)	.1017
Commission (sales and purchase)	.4018
Outside professional service (lawyer, etc.)	.2019
B. Operating expenses	.0100
Operating supplies—parts and repl. items	.3101
Repairs and stockroom materials	.2102
Small tool supplies	.2103
Fuels and lubricants	.3104
Electricity	.3105
Water	.3106
Freight postage	.4107
Auto and truck expense	.4108
Travel expense (for crew)	.3109
Shipping containers and supply items	.4110
Equipment rental	.3111
Membership dues	.2112
Subscriptions	.2113
Telephone and telegraph	.3114
Rental for real estate	.2115
Office supplies and stationery	.2116
C. Timber and lumber account	.0200
Log purchase	.4201
Advance against purchase to outside log source and yard	.4202
Lumber purchase outside source	.4203
Stumpage	.4204
D. Depreciation account	.0300
Machinery and equipment	.1301
Building and structure	.1302
Grounds and yards	.1303
Autos and trucks	.1304
Furniture and fixtures	.1305
RR tracks	.1306
Capitalized office equipment (eqpt. that cannot be placed under expenses)	.1307
E. Insurance account	.0400
Employees group insurance	.2401
Auto and truck	.2402
Plant property	.1403
Bonds and securities	.2402
Liability	.2405
Inventory	.2406
Insurance (misc.)	.2407
F. Tax Account	.0500
Local property	.1501
Privilege taxes and licenses	.2502
State income tax	.4503
Federal income tax	.4504
Social Security	.3505
Unemployment insurance	.3506
Miscellaneous taxes	.2507
G. Donation and gift	.0600
H. Advertising	.4700
I. First aid and transportation	.2800
J. Miscellaneous account	.0900
Employees activities	.2901
Holiday and vacation provision	.3902

anatomical features of permeable and refractory douglas-fir[1]

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THE PENETRATION OF LIQUIDS into wood is important in both the pulp and paper industry and the wood preserving industry. Wood chips for paper must be completely penetrated with cooking liquors to insure a uniform separation of wood fibers. Without proper penetration, the outside fibers of the chip become overcooked and the chip center remains undercooked or chars. The primary objective in wood preservation is to increase the service life of wood through the penetration and retention of a toxic preservative.

The impregnation of wood with any liquid is a complicated chemical, physical, and anatomical problem. Douglas-fir heartwood is no exception, and the problem is further complicated because the resistance to penetration varies greatly within this species.

Douglas-fir heartwood samples collected by the Oregon Forest Research Center from sawmills throughout Oregon were treated with creosote (6). A distinct difference in the degree of permeability was noted in this material. Their results indicated that Douglas-fir heartwood from eastern Oregon was generally much less permeable than the material from the western half of the state.

Review of Literature

Two forms or varieties of Douglas-fir are recognized. The Rocky Mountain form (variety *glauca*) and the Pacific Coast form (variety *menziesii*) are classified according to morpholoical and environmental differences. Anatomical differences of both forms of the wood cannot normally be distinguished. The two forms differ somewhat in size and the color of foliage, but the principal botanical difference is in the structure of their cones (5). Also, they have been found to differ in strength properties and ease of treatability.

Douglas-fir wood is composed of many channels for liquid movement. Because the samples used in this study were rated almost entirely on the amount of longitudinal penetration, the anatomical features which affect penetration in this direction are discussed.

The major passageways for flow in the longitudinal direction are through the tracheids and resin ducts in Douglas-fir. Resin ducts probably are not responsible for complete penetration since they are not always free to conduct liquids. Also, if liquid distribution through the surrounding cells is not sufficient, resin ducts would not account for springwood penetration because they are located primarily in the summerwood zone of the growth ring.

I. W. Bailey (1)[2] observed the flow of carbon particles from tracheid to

[1] A 1960 Wood Award entry. Revised for publication June, 1961.

[2] Numbers in parentheses refer to Literature Cited at the end of this report.

The Author: R. L. Krahmer is a graduate student, Department of Wood Engineering, College of Forestry, State University of New York, Syracuse.

Such anatomical features as tracheid length, springwood lumen cross section, and the diameters of the bordered pit-pair structures (aperture, torus, annulus) were analyzed statistically. They were then related to permeable and refractory behavior of Douglas-fir heartwood to liquid penetration.

tracheid and concluded that the particles traveled through the bordered pits. Since this observation, the relationship of pits to permeability has been carefully studied.

Initial work on the flow of liquids under pressure through the tracheids were designed to determine which structures or conditions offered the greatest resistance to penetration. Stamm (7) conducted experiments which showed the major resistance to flow in the longitudinal direction was in the bordered pit openings in the cell walls. In a review of literature on pit studies, Stone (8) found that aspirated pits were more abundant percentagewise in refractory woods. In later studies, however, he concluded that the surface of the torus was too rough to completely seal the aperture to flow of most liquids. Other research on bordered pits has been devoted primarily to the dividing membrane of the pit-pair. Electron micrographs by Côté (2) show this membrane as microfibrillar strands which radiate from the torus to the outer edges of the pit cavity. In the heartwood pits of certain species, the porosity of this membrane appears reduced by encrustations on these strands.

Fleischer (3) found the lumen cross-sectional area to be larger in permeable Douglas-fir. Since a correlation between tracheid length and lumen area has been observed (4), it might also be expected that the tracheids were longer in the permeable sample.

Techniques

The samples for this study were obtained from material that had been rated refractory or permeable to liquid penetration. Preliminary investigation of fiber length, lumen cross section, and pit diameters were made on seven samples of Douglas-fir heartwood. Three samples were rated permeable and four rated refractory.

The fiber length analysis indicated that more specimens in each group should be used. For this portion of the study, 17 additional samples were obtained, making a total of 12 permeable and 12 refractory samples. All samples of permeable wood were from locations in the Pacific Coast region, while all but one of the refractory samples were from eastern Oregon. Table 1 shows the location by town of the samples used.

Fiber length measurements were made with a microscope and a calibrated eyepiece. The macerated wood included fibers from the full range of annual rings represented on the heartwood sample. A total of 180 fibers from the permeable woods and 200 fibers from the refractory woods were measured. Springwood and summerwood fibers were not separated.

Fiber lumens were measured from the cross sections of the seven Douglas-fir samples. Three photographs were taken of each sample; each picture represented one growth ring. The pictures from each sample were taken from areas representing different radial groups of tracheids. Measurements were taken directly from the enlarged photographs. Radial and tangential diameters of only the springwood fiber lumens were measured. Springwood appeared to be the limiting factor for good treatability since creosote concentration was in the summerwood of the semipermeable woods.

The diameters of the bordered pit annulus, torus, and aperture were measured directly from radial wood sections with a microscope. Since a complete cell wall of any one fiber was not present, areas where pits were present had to be chosen for study. Fifteen pits were measured from the springwood zone of each sample.

Results

The fiber length analysis indicated that the average fiber length of the permeable and refractory Douglas-fir wood differed greatly (Table 2). The permeable group ranged from 5.06 to 6.16 millimeters in length, and the group average was 5.59 millimeters. The refractory samples ranged from 3.19 to 4.09 millimeters, and the group average was 3.68 millimeters. The average fiber length for each wood sample is given in Table 1. These are ranked in order of decreasing length to show the range within a group, and the order does not necessarily indicate degree of permeability within a group.

For the lumen measurements, the radial and tangential dimensions were

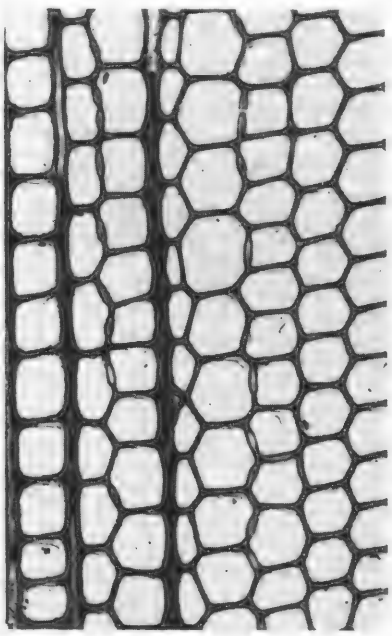

Fig. 1.—Cross section of a permeable Douglas-fir heartwood sample (270X).

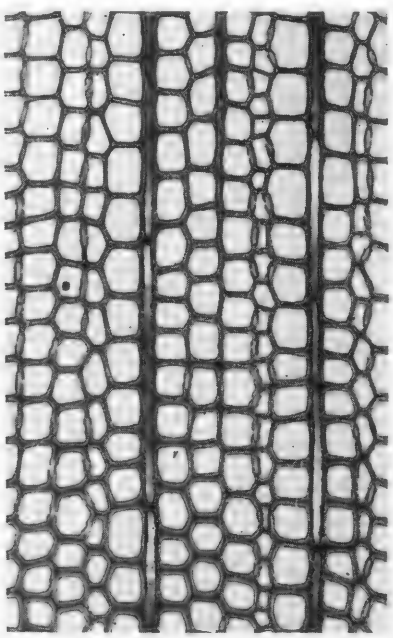

Fig. 2.—Cross section of a refractory Douglas-fir heartwood sample (270X).

Table 1.—SUMMARY OF RESULTS

Sample No.	Location	Average Fiber Length millimeters	Average Lumen Size Radial (microns)	(Tangential (microns)
		Permeable Woods		
89	Cottage Grove	6.16	-----	-----
28	Eugene	6.07	-----	-----
38	West Fir	5.99	-----	-----
94	Dallas	5.84	-----	-----
90	Cottage Grove	5.72	-----	-----
42	Tillamook	5.57	-----	-----
19	Glendale	5.47	-----	-----
*20	Glendale	5.45	39.96	36.66
14	Medford	5.34	-----	-----
*88	Cottage Grove	5.24	40.22	34.50
*30	Eugene	5.17	40.79	35.67
10	Coos Bay	5.06	-----	-----
	Average	5.59	40.32	35.61
		Refractory Woods		
*33	Heppner	4.09	25.06	27.39
32	Heppner	4.03	-----	-----
51	La Grande	4.00	-----	-----
57	Prineville	3.90	-----	-----
*65	St. Helens	3.84	27.82	23.95
56	Prineville	3.81	-----	-----
36	Hines	3.69	-----	-----
*50	La Grande	3.54	31.92	27.77
*34	Hines	3.48	27.05	27.64
4	Mt. Vernon	3.36	-----	-----
35	Hines	3.22	-----	-----
101	Kinzua	3.19	-----	-----
	Average	3.68	27.96	26.69

*Samples used in preliminary studies.

Table 2.—ANALYSIS OF VARIANCE: EFFECT ON PERMEABILITY

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Fiber Length (24 Samples)				
Between Groups	1	10,469.067	10,469.067	189.58*
Samples in Group	22	1,214.921	55.224	4.77*
Error	356	4,118.152	11.568	
Total	379	15,802.140		
Tangential Lumen Size (7 Samples)				
Between Groups	1	1,959.2719	1,959.2719	48.42*
Samples in Group	5	202.3399	40.4680	7.11*
Zone in Ring	7	39.8558	5.6937	0.61
Error	852	7,956.9874	9.6937	
Total	865	10,158.4550		
Radial Lumen Size (7 Samples)				
Between Groups	1	1,866.4543	1,866.4543	52.40*
Samples in Group	5	178.0912	35.6182	1.18
Rings in Sample	14	423.6639	30.2617	3.74*
Error	441	3,564.3274	8.0824	
Total	461	6,032.5368		
Pit Annulus Size (7 Samples)				
Between Groups	1	0.5571	0.5571	12.87
Samples in Group	5	0.2165	0.0433	3.55
Rings in Sample	14	0.1710	0.0122	1.03
Error	84	1.0010	0.0199	
Total	104	1.9456		
Pit Aperture Size (7 Samples)				
Between Groups	1	0.0580	0.0580	5.09
Samples in Group	5	0.0568	0.0114	4.22
Rings in Sample	14	0.0373	0.0027	1.00
Error	84	0.2270	0.0027	
Total	104	0.3791		
Pit Torus Size (7 Samples)				
Between Groups	1	0.0909	0.0909	8.82
Samples in Group	5	0.0513	0.0103	5.12
Rings in Sample	14	0.0343	0.0025	0.66
Error	84	0.3160	0.0038	
Total	104	0.4925		

*Significant at 1 percent level.

recorded separately, and therefore a separate analysis was made on each rather than combine them as a lumen area (Table 2.) For all samples measured, the permeable woods had significantly larger lumens. The average dimensions are given in Table 1.

The diameters of the bordered pit structures showed no relationship to the permeability of Douglas-fir heartwood, although there appeared to be a higher frequency of fibers with double rows of pits on the radial wall in the permeable samples. This observation was evident on both radial and cross sections. In the permeable samples the fiber cross sections show a greater tendency toward having more than four sides. Since the texture in the radial direction is also coarse, the radial wall of these fibers is generally wide enough to support more than one vertical row of bordered pits. Often one of the rows of pits appeared to lead to one adjacent fiber lumen, and the second row of pits to another adjacent lumen (Figure 1). The fibers of the refractory woods were more square in cross section and finer textured. Their radial walls tended to have only one vertical row of pits (Figure 2).

The effect of these anatomical characteristics on permeability was not studied. However, since the initial permeability studies appeared to represent a known difference between permeability of Pacific Coast and Rocky Mountain forms of Douglas-fir, these structural differences may be a morphological characteristic of these two forms.

Conclusions

The results of this study on the anatomical differences between permeable and refractory Douglas-fir heartwood offer several conclusions.

The average fiber length of the permeable group of woods is considerably longer than that of the refractory woods. The springwood lumen area is largest in the permeable woods. The permeable and refractory woods have bordered pit structures of the same diameter.

Fibers in the permeable woods appear more hexagonal in cross section with a radial wall capable of supporting a double row of bordered pits, while in the refractory woods the fibers are more square in cross section with one row of bordered pits on the radial wall.

All factors related to permeability of wood must be considered before any one factor or combination of factors can be successfully correlated with permeability. In Douglas-fir, the nature of the extractives and possible variations in the ultra-structure of the wood may also account for the difference in permeability.

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Studies on Lignin and Related Products. XV.

Lignosulfonates of B

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Experiments on the fractionation of a commercial birch spent sulfite liquor by means of ion exchange are reported here. Also included are birch lignosulfonate oxidation studies employing both alkaline cupric oxide and alkaline silver oxide as oxidizing agents in an attempt to compare such oxidations with analogous oxidations of aspen lignosulfonates.

STUDIES ON THE SEPARATION of the lignosulfonates and carbohydrates of aspen spent sulfite liquor by ion-exchange was reported in an earlier paper (1).[2] These studies indicated that the lignosulfonates and carbohydrates of aspen spent sulfite liquor could be separated by certain anion-exchange resins provided the liquor was first decationized. In the case of coniferous spent sulfite liquor, Van Blaricom and Gray (2) were able to obtain lignosulfonates completely free of carbohydrate contamination by the use of anion-exchangers without previous decationization. Other studies in our laboratories (3,4,5) on aspen lignin and aspen lignosulfonates led us to believe that aspenwood might be different from other representative hardwoods, and that this difference might be responsible for the failure of aspen spent sulfite liquor to respond to ion-exchange processes found to satisfactorily separate carbohydrate from lignosulfonate fractions in coniferous spent sulfite liquors. Furthermore, it was possible that the spent sulfite liquors of other hardwoods might react differently toward the ion-exchange procedure evolved earlier (1) for the separation of carboyhdrate and lignosulfonate fractions in aspen spent sulfite liquor.

Ion-Exchange Studies

A concentrated commercial birch spent sulfite liquor was diluted and passed through a regenerated column of Duolite A–2M, the aion-exchange resin found to give the best separation of carbohydrates in coniferous spent sulfite liquors (2) and in aspen spent sulfite liquors (1). As in the case of the aspen liquors, separation was incomplete, and no lignosulfonate fractions could be obtained free of carbohydrates, and no carbohydrate fractions could be obtained free of lignosulfonates. Accordingly, recourse was made to the two-step procedure evolved for quantitative separation of lignosulfonates from carbohydrates in aspen spent liquors.

The birch spent sulfite liquor was first decationized by passing through a regenerated column of Amberlite IR–120 cation-exchange resin. The methoxyl recovery in this operation amounted to only 93 percent compared to a substantially quantitative recovery in the case of the aspen liquor. This suggests the breakdown of some methoxyl-containing materials during the decationizing process.

The decationized liquor was passed over Duolite A–2M anion-exchange resin, and the resin was washed with water. The column was then eluted with sodium hydroxide solution. On the basis of solids and methoxyl analyses, described earlier (1), the separation of lignosulfonates and carbohydrates in the decationized birch spent sulfite liquor was 97 percent based on the recovered methoxyl. The methoxyl recovery was 94 percent.

In a similar experiment with Duolite A–6 anion-exchange resin, the separation of lignosulfonates and carbohydrates in the decationized liquor was 84.5 percent based on the recovered methoxyl, and the methoxyl recovery was 86.0 percent. Thus, Duolite A–2M gave an almost quantitative recovery and separation of lignosulfonate and carbohydrate fractions

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 15, Division 4 (Chemical Conversion), June 22, 1961. For paper XIV of this series, see Pearl, I. A. 1959. J. Org. Chem. 24:736. This paper represents a portion of the results obtained in the research program sponsored by the Sulphite Pulp Manufacturers' Research League and conducted for the League by The Institute of Paper Chemistry.

[2] Numbers in parentheses refer to Literature Cited at the end of this report.

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f Birch Spent Sulfite Liquor

from birch decationized liquor, whereas the recovery and separation obtained with Duolite A–6 was only fair. This result was reminiscent of the experience with aspen decationized liquor (1).

Birch Lignosulfonate Oxidation Studies

The birch spent sulfite liquor was oxidized with alkaline cupric oxide and with alkaline silver oxide under the conditions employed in the previous study with aspen spent sulfite liquors (6). Like aspen liquors, the insecure status of birch "lignin" and its methoxyl content along with the similar status of the lignin content of hardwood lignosulfonates led to the employment of total solids as the basis for calculation of reactant ratios.

The alkaline oxidation mixtures were acidified and extracted continuously with ether. The ether extracts were chromatographed in the butanol-2 percent aqueous ammonia, 10:3:3 butanol-pyridine-water and 0.3*N* sulfurous acid systems at 20° C., and the chromatograms were examined under ultraviolet light and sprayed with the bis-diazotized benzidine, 2,4-dinitrophenylhydrazine, ferric chloride, and Mäule reagents. On the basis of these chromatograms and comparison with known compounds, the presence of compounds were determined. Qualitative chromatograms of the cupric oxide oxidation indicated the presence of vanillin, syringaldehyde, acetovanillone, acetosyringone, vanillic acid, syringic acid, and *p*-hydroxybenzoic acid. In addition, two new compounds never found in analogous oxidations of aspen spent sulfite liquors were indicated, but not identified. Qualitative chromatograms of the silver oxide oxidations indicated the presence of vanillin, syringaldehyde, acetovanillone, acetosyringone, vanillic acid, syringic acid, *p*-hydrobenzoic acid, and ferulic acid along with several unidentified compounds.

The above-noted compounds found in these oxidation mixtures were then determined quantitatively by chrommatographic and spectrophotometric procedures recently developed in connection with other work in our laboratory on the alkaline hydrolysis of representative hardwoods and reported in detail previously (5, 6, 7). Quantitative data for the cupric oxide and silver oxide oxidations are given in Tables 1 and 2, respectively.

Discussion of Results

The cupric oxide oxidation of the birch spent sulfite liquor gave a yield of 21.2 percent ether extractives on the basis of the starting solids. This yield is very close to that obtained in the analogous study with aspen spent sulfite liquor (6). It should be noted that if a 20 to 21 percent methoxyl in hardwood lignin be accepted for birch lignin, and if all methoxyl in the birch liquor can be attributed to lignin, the yield of ether extractives in this experiment would be 51 to 52 percent on the lignin basis. Similarly, the yield of ether extractives from the silver oxide oxidation was 12.0 on the basis of the total solids. Again, if the previously accepted values for methoxyl in birch lignin be assumed, the yield on the lignin basis would be 28.5 to 29.5 percent on the lignin basis.

The finding of *p*-hydroxybenzoic acid in these experiments on birch liquor was surprising in view of the previously reported results obtained on the alkaline hydrolysis of pure species of birch (5). In the earlier experiments, paper birch *(Betula papyrifera)* and yellow birch *(Betula lutea)* were

Table 1.—CUPRIC OXIDE OXIDATION OF BIRCH SPENT SULFITE LIQUOR

Compound	Yield, Percent	
	Ether extractives basis	Original solids basis
Total ether extractives	----	21.2
Vanillin	5.23	1.11
Syringaldehyde	9.90	2.09
Acetovanillone	1.46	0.31
Acetosyringone	5.83	1.23
Vanillic acid	3.55	0.75
Syringic acid	5.17	1.09
p-Hydroxybenzoic acid	0.50	0.11

Table 2.—SILVER OXIDE OXIDATION OF BIRCH SPENT SULFITE LIQUOR

Compound	Yield, Percent	
	Ether extractives basis	Original solids basis
Total ether extractives	----	12.0
Vanillin	1.14	0.14
Syringaldehyde	0.95	0.12
Acetovanillone	0.64	0.08
Acetosyringone	2.04	0.25
Vanillic acid	12.82	1.55
Syringic acid	22.30	2.68
p-Hydroxybenzoic acid	1.30	0.16
Ferulic acid	4.04	0.49

Table 3.—FRACTIONATION OF DECATIONIZED BIRCH SPENT SULFITE LIQUOR ON ANION-EXCHANGE RESINS

	Duolite A-2M	Duolite A-6
Starting liquor		
Total solids, g.	36.2	36.2
Methoxyl, g.	4.0	4.0
Effluent		
Total solids, g.	15.9	15.2
Methoxyl, g.	0.12	0.54
Sodium hydroxide eluate		
Total solids, g.	35.7	29.8
Methoxyl, g.	3.63	2.89
Combined fractions		
Total solids, g.	51.6	45.0
Methoxyl, g.	3.75	3.43
Methoxyl recovery, percent	94	86
Separation, percent [1]	97	84.5

[1]Separations of lignosulfonate and carbohydrate materials are calculated from the ratio of methoxyl recovered in the sodium hydroxide eluate to the total recovered methoxyl.

boiled with 4 percent sodium hydroxide solution under reflux. Under these conditions, no *p*-hydroxybenzoic acid, *p*-hydroxybenzaldehyde, or *p*-coumaric acid were found. It is possible that, in the present copper oxide oxidation, portions of the birch lignin complex containing only *p*-hydroxybenzyl moieties could be oxidized to *p*-hydroxybenzoic acid, but the fact that no *p*-hydroxybenzaldehyde was found indicates that this was not probable. It is more likely that the *p*-hydroxybenzoic acid originated in other hardwood logs such as aspen contained in the original "birch" furnish to the sulfite mill. The amount of *p*-hydroxybenzoic acid was very low compared to other products of these oxidation reactions and with yields of p-hydroxybenzoic acid obtained in similar oxidations of aspen lignosulfonates.

As in the case of the previous silver oxide oxidation of aspen spent liquor (6), silver oxide oxidation of the birch spent liquor yielded ferulic acid. The earlier isolation of ferulic acid and its related acid, *p*-coumaric acid, from aspen lignosulfonate oxidation mixtures was the first time that such acids with three-carbon side chains had been isolated from lignosulfonate oxidation mixtures. The ferulic acid found in the present day study on birch spent sulfite liquor indicates that the previous results were not restricted to aspen-drived lignosulfonates, and suggests that ferulic acid might be an oxidation product of other hardwoods. The failure to find ferulic acid in the cupric oxide oxidation of birch spent sulfite liquor suggests that under the conditions of cupric oxide oxidation, moieties in the birch lignosulfonate complex which gave ferulic acid under silver oxide oxidation conditions gave vanillin and vanillic acid or both.

The low recovery of the compounds listed in Tables 1 and 2 in the ether extractives after oxidation of birch spent sulfite liquor indicates that the major portion of these ether extractives are still unknown. In the case of the cupric oxide oxidation, two phenolic materials appear to comprise a large portion of this unknown material. The rest must be composed of compounds which give no reactions with the spray reagents employed for the location of spots on chromatograms. In the case of the silver oxide oxidation, no phenolic compounds appear to be present in quantity, and any or all other major constituents of the ether extract must be materials which do not give reactions with the spray reagents employed.

The differences in the syringyl-guaiacyl ratios of the birch liquor oxidations and the previous aspen liquor oxidations (6) is worthy of note. For the previous cupric oxide oxidation of aspen spent sulfite liquor, the weight ratios for syringaldehyde:vanillin, acetosyringone:acetonvanillone, and syringic acid:vanillic acid were 1.28, 2.52, and 1.14, respectively. In the present study on an analogous oxidation of birch spent sulfite liquor, these ratios were 1.89, 3.19, and 1.45, respectively. Similarly, for the silver oxide oxidation the ratios for the aspen liquor were 0.47, 2.49, and 1.18, and those for the birch liquor were 0.83, 3.26, and 1.74. These data indicate that the birch lignosulfonate complex contains a higher ratio of syringyl moieties to guaiacyl moieties amenable to oxidation by the alkaline cupric oxide and silver oxide procedures to these monomolecular products than does the aspen lignosulfonate complex.

Pearl

Beyer

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Starting Materials

The spent sulfite liquor employed in these studies was a commercially concentrated spent liquor from the experimental commercial pulping of birchwood (predominantly *Betula papyrifera*) by the calcium-base acid sulfite process. The concentrated liquor contained 64.4 grams of total solids per 100 grams of liquor, and the solids contained 8.3 percent methoxyl. This liquor was obtained through the courtesy of the Sulphite Pulp Manufacturers' Research League in February, 1957.

Ion-Exchange Resins: Duolite A–2M, Duolite A–6, and Amberlite IR-120 are commercial resins described earlier (1).

Experimental

Separation of Carbohydrates and Lignosulfonates: The decationization of the original birch liquor and processing of the decationized liquor followed the procedure detailed in the previous paper (1). The data are found in Table 3.

Oxidations of Birch Spent Sulfite Liquor: Alkaline cupric oxide oxidation of birch spent sulfite liquor followed the procedure described earlier (9). Qualitative paper chromatography of the ether extractives indicated the compounds of Table 1 plus two compounds with R_f's of 0.14 and 0.15 in the butanol-aqueous ammonia developer. Both compounds have the same R_f of 0.64 in 10:3:3 butanol-pyridine-water, and both give a bright yellow fluorescence under ultraviolet light. Quantitative data for the identified compounds are also given in Table 1.

Alkaline silver oxide oxidation followed the procedure described earlier (6), and quantitative data for the identified compounds are given in Table 2.

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Effect of Thermal Degradation on Shrinkage and Collapse of Wood from 3 Australian Species[1]

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Thermal degradation of green wood causes large increases in total shrinkage due to increased collapse during subsequent drying, and severely reduces the recovery obtainable by reconditioning. Increase in shrinkage is roughly proportional to increase in acidity up to the maximum. When acidity decreases, there is no further change in shrinkage or loss of recovery.

COLLAPSE OF THE CELLS may cause severe degrade in sawn lumber of certain woods during seasoning by both air and kiln drying methods. In a great many other species, collapse occurs only if the wood is heated for prolonged periods to temperatures higher than about 60° to 80° C. prior to or early during drying, when many cells are still above fiber saturation point.

Collapse, as distinct from "normal" shrinkage, was first recognized by Tiemann (1)[2] nearly 50 years ago. To explain this phenomenon, in 1915 Tiemann proposed the liquid tension theory (2), whereas Stamm and Loughborough attempted an explanation in terms of compression stresses (3). Detailed discussions of research on collapse have been published by Greenhill (4) and by Ellwood and associates (5).

A synthesis of the modes of action of the liquid tension and compression stress theories in *Eucalyptus regnans* was presented by the writer in 1960 (6). A correlation was established between liquid tension collapse and deformation induced by external mechanical compression of the wood, and it was shown that collapse took place when the inducing forces exceeded the strength of the cell walls at the limit of plastic flow. Total collapse was found to be a linear function of wood temperature, and, to a smaller extent, of the collapse-free shrinkage. A theoretical equation was proposed which correctly predicted the observed collapse at each temperature on the basis of surface tension data and of structural and rheological properties of the wood.

[1] Presented at the 1961 Annual Meeting of the Forest Products Research Society, Louisville, Ky., Session 10, Division 8 (Drying B), June 21, 1961.

[2] Numbers in parentheses refer to Literature Cited at the end of this report.

The author expresses his thanks to his colleagues: Mr. E. R. Pankevicius, Miss N. Ditchburne, and Mr. C. M. Stewart.

The Author: Dr. W. G. Kauman obtained Applied Science Diploma of Melbourne Technical College in 1952; B.Sc. of Melbourne University in 1953; and at Brussels Free University graduated Licencié Spécial in 1957, and Docteur en Sciences in 1959. He has been with the Division of Forest Products, C.S.I.R.O., since 1948, and is now a Senior Research Officer.

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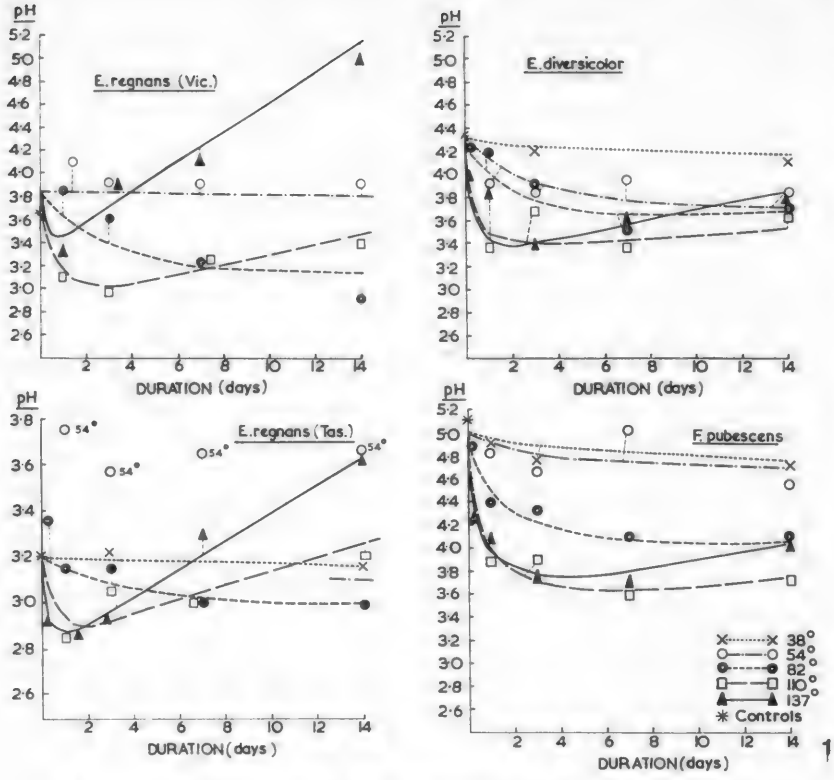


Fig. 1.—Acidity of specimens after heat treatments (pH measured after extraction with 10 milliliters of water per gram of wood).

The increase of collapse with drying temperature reported in the work previously cited is a result of reversible changes in the rheological behavior of the cell walls. In addition, irreversible changes may be caused in the wood substance by thermal degradation when green wood is heated excessively. It is with the effect of these irreversible changes on shrinkage and collapse that the present work is mainly concerned.

Review of Literature

Research on the thermal degradation of wood has been going on for at least a century. Most research workers were interested in the effect of heat on chemical composition and strength, and their findings are reviewed in standard textbooks (7, 8, 9). It is generally agreed that heat treatments affect first and foremost the more reactive noncellulosic polysaccharides before attacking the cellulosic polysaccharides and lignin, and reduce all strength properties. To heat in the presence of water causes considerably more degradation than dry heating, and temperatures as low as 50° C. may markedly reduce strength if applied at length (10, 11). Heat treatments are also known to stabilize wood dimensionally, although at the cost of embrittlement (12).

When one considers the large volume of research on thermal degradation, it is surprising that only a few workers have examined the effect of excessive heating of green wood on the shrinkage during subsequent drying. This effect can be important during kiln drying of lumber from the green state at elevated temperatures. It must also be considered when green wood is exposed to high temperatures for steaming, preheating, or immunizing.

Koehler (13) observed increases in the shrinkage of red oak and yellow birch heated in the green state at 134° C. for 6 hours and then air-dried, but his heating treatments at lower temperatures were too short to produce an effect. Kapur and Rehman (14) have reported increased shrinkage in lumber of various Indian species steamed before drying, and Stevens (15, 16) found an increase in the shrinkage of European beech with increase in drying temperature. Similar increases were reported for Australian species by Greenhill (17) and Gottstein (18), and for Japanese cypress by Ohnuma and Saito (19).

These increases in shrinkage after exposure of the green wood to temperatures of the order of 100° C. were very probably due to collapse, even in species that normally do not collapse during drying at low temperatures. The only specific investigation on the influence of preheating on collapse has been carried out by Greenhill (4) with *E. regnans* F. Muell. He found that in the material investigated, collapse increased fourfold after heating at 100° C. for 2 days or at 82° C. for 32 days. At the same time, the preheating severely reduced the recovery obtained from reconditioning. For treatments longer than about 4 days at 100° C., the collapse became almost completely irrecoverable. Greenhill made, however, no attempt to correlate this collapse behavior with the thermal degradation of the material.

Bryan (20) reported that heating of Pacific madrone below 20 percent moisutre content at 71° and 82° C. significantly increased collapse and slightly inhibited recovery. His results are not directly comparable with those cited above, as thermal degradation is less severe in unsaturated wood (11). Kemp (21) investigated the effect of temperature and humidity on time-to-collapse in aspen, but the changes induced by his treatments were probably largely reversible.

On the other hand, several investigators have attempted to trace the chemical changes in wood heated over a comparable temperature range. Their observations show that the production of acid provides a sensitive measure of the progress of thermal degradation (22, 23). The acid arises very probably from hydrolysis of the o-acetyl groups in the wood (7, 24, 25, 26).

The present writer considered that the increase in collapse after preheating was most likely related to weakening of the cell wall by hydrolysis or other irreversible chemical changes (6). The experiment described hereafter was therefore designed to determine the relation between the increased collapse and the acidity of the specimens after heat treatments at temperatures from 38° to 137° C. for periods from 6 hours to 14 days. In addition to material of the severely collapse-susceptible species *E. regnans* from two different localities, it was decided to include wood of *E. diversicolor* F. Muell., a species prone to only slight collapse but liable to split freely during drying, and of the normally non-collapsing species, *Flindersia pubescens* F. M. Bail.

Theoretical Considerations

Thermal decomposition of wood, at least in its earlier stages, is known

to produce acetic and some other acids by hydrolytic processes and is generally considered to obey first order rate laws (7, 11, 27). Some of the acid will migrate from the site of its production by diffusion and may eventually be lost from the specimen by direct or steam distillation (26). There does not appear to be any evidence in the literature that some of the acid is consumed in secondary reactions.

Although the products of the thermal degradation reaction are fairly well known, the starting point and detailed mechanism are still in doubt. A simple kinetic model which assumes decomposition of a single substance to form acid is proposed therefore as a useful first approximation to a quantitative description under the conditions of the present experiment. We shall assume that two processes occur simultaneuosly: an acid-producing proccess, and an acid-eliminating process.

Both processes are assumed to obey first order rate laws. They will be represented by the reactions:

$$X \longrightarrow H \qquad u_1 = k_1 X$$
$$H \longrightarrow Y \qquad u_2 = k_2 H$$

In this scheme, an unknown substance (X) decomposes with velocity (u_1) to form acid (represented by hydrogen ion concentration H), and the acid transforms with velocity u_2 to state Y in which it is lost to the system.

The rate constants are k_1 and k_2, respectively.

The system is described by the differential equations

$$\frac{dX}{dt} = k_1 X \qquad \text{--------(1)}$$

$$\frac{dH}{dt} = k_1 X - k_2 H \qquad \text{-------(2)}$$

where t = time.

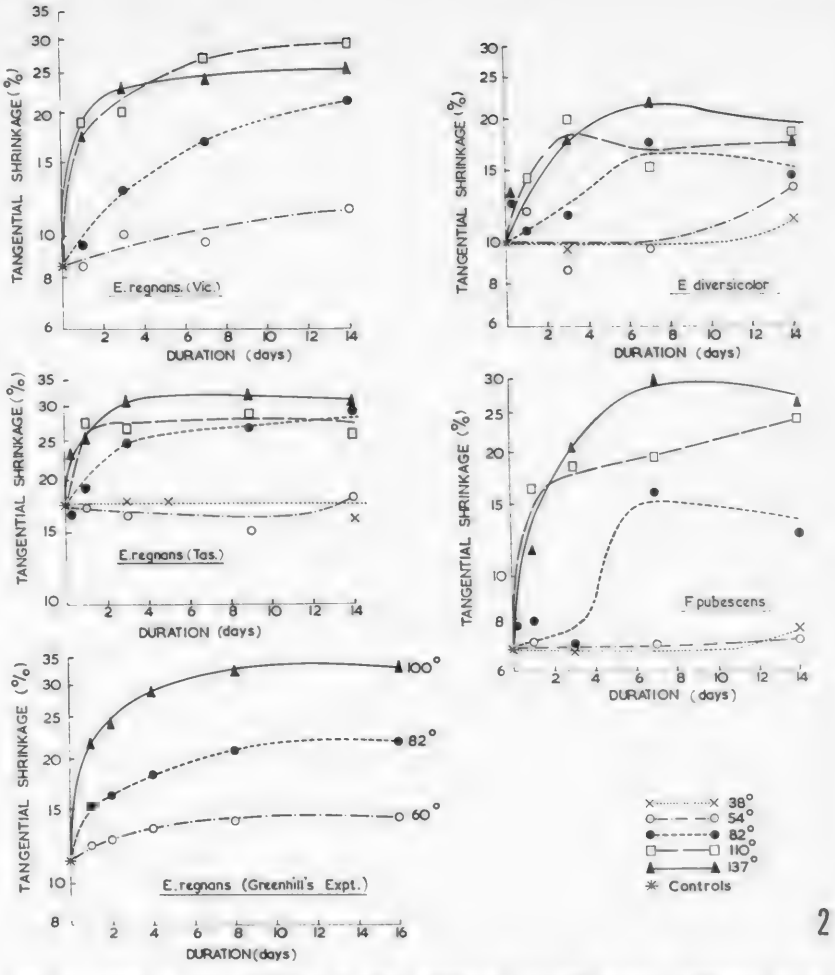
If $H = H_0$ and $X = X_0$ when $t = 0$, the solutions of (1) and (2) are

$$\frac{X}{X_0} = e^{-k_1 t} \qquad \text{------(3)}$$

$$\frac{H}{H_0} = \frac{k_1 B}{k_1 - k_2}\left\{ e^{-k_2 t} - e^{-k_1 t} \right\} + e^{-k_2 t} \qquad \text{-(4)}$$

where $B = X_0/H_0$.

Equations (3) and (4) contain only three unknown parameters, X_0, k_1, and k_2. In the absence of quantitative analytical information on the variation of the concentration of X with time, these can only be determined from observations of H. The following approximate relations are readily derived from (4), assuming k_1 is at least several times greater than k_2,



2

Fig. 2.—Effect of heat treatments on total tangential shrinkage during subsequent drying.

$$k_2' \approx \frac{1}{\tau_2 - \tau_1} \ln \frac{H_1}{H_2} \quad (\tau_2 > 1,\ \tau_2 > \tau_1) \qquad \text{-(5)}$$

$$B \approx \frac{(H_{max}/H_0) - e^{-k_2'}}{e - k_2'} \qquad \text{----------(6)}$$

$$\frac{k_1'}{k_1' e} \approx \frac{k_2'}{B} + k_2' \qquad \text{----------(7)}$$

$$\ln \frac{k_1' C}{k_2' (C+1)} \approx k_1' - k_2' \qquad \text{--(8)}$$

where the prime signifies multiplication of the rate constants by t_M (t_M = time for H_{max}) and $\tau = t/t_M$, $C = Bk_1'/(k_1' - k_2')$. H_1 and H_2 designate the values of H at time τ_1 and τ_2, and ln means logarithm to base e.

Using relations (5) to (8), equation (4) may be fitted to a set of experimental data. It should be noted that the three parameters X_0, k_1, and k_2 are not entirely arbitrary.

Thus, since X_0 designates the amount of substance X present in untreated wood, it should be constant at all temperatures. However, some scattering might be expected because the assumption of a single decomposing substance X constitutes only a rough description of the complicated thermal degradation process.

The logarithm of each of the rate constants k_1 and k_2 should be a linear function of the inverse absolute temperature, T, as may be deduced from the wellknown relation

$$k = A \exp(-E/RT) \qquad \text{------(9)}$$

where A is a constant, E the activation energy of the reaction and R the universal gas constant. The reaction kinetics will be further discussed in a forthcoming paper.

Table 1 shows the parameters obtained by fitting equation (4) to the results of the present experiment. Equations (5), (6), and (7) were used to calculate k_2, B, and k_1 to a first approximation. A second approximation for k_1 and B was then obtained from equation (8) by iteration, and the values thus found are given in the table. In general, the second approximation gave an improvement of about 10 percent of the first approximation.

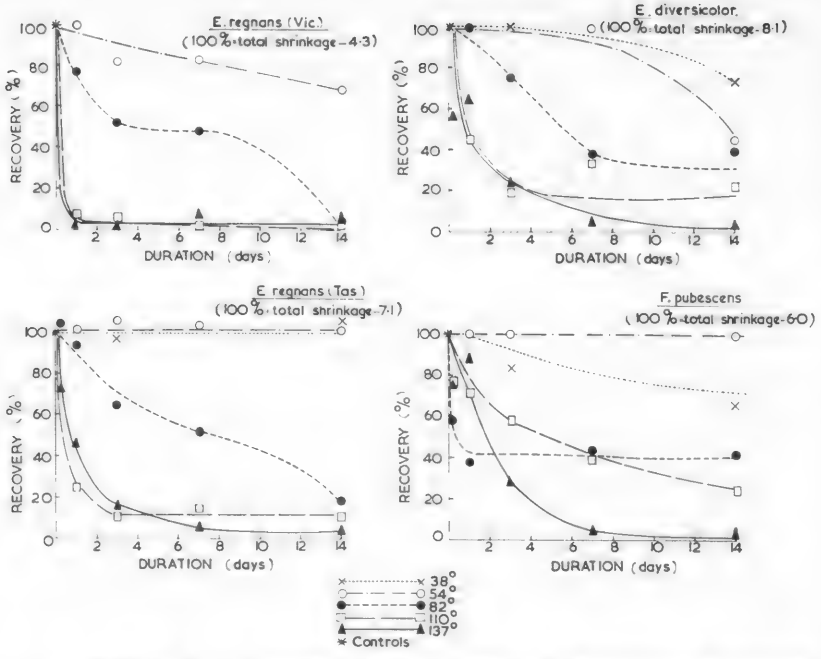


Fig. 3.—Effect of heat treatments on recovery obtained from reconditioning after drying (recovery in percent of difference between total shrinkage before reconditioning and shrinkage of controls after reconditioning).

Experimental Procedure

The experimental material was selected from the heartwood of three sound, mature trees of each of the following lumbers: *E. regnans* (mountain ash) grown in Victoria, *E. regnans* grown in Tasmania, *E. diversicolor* (karri), and *Flindersia pubescens* (silver ash). A board measuring approximately 4 by 1 by 16 inches was taken from each of the 12 trees and sawn into fifty-six 1-inch cubes. End-matched pairs of cubes were distributed at random to 28 test groups, so that each group comprised 12 pairs, including 1 from each tree. Twenty-one test groups were allotted to the heat treatments shown below, the remainder being kept in reserve (Victorian *E. regnans* was only included in 17 groups).

HEAT TREATMENTS

Temperature (°C.)	Duration (days)				
20	Controls				
38			3*		14*
54		1	3	7	14
82	¼*	1	3	7	14
110		1	3	7	14
137	¼*	1	3	7	14

*These treatments were omitted in the case of Victorian E. regnans.

The heat treatments were given by enclosing the green specimens in stainless steel bombs which were then placed in an oven at the required temperature. Twenty milliliters of water was added to each bomb to ensure a saturated atmosphere, except in the case of Victorian *E. regnans,* where the water contained in the specimens was relied upon to provide saturation. Each bomb contained three pairs of specimens of the same species, supported on matched dummy specimens to prevent contact with the water. At the end of each treatment, the specimens were withdrawn as soon as the bombs had cooled sufficiently to ensure that the inside pressure did not exceed atmospheric.

After withdrawal from the bombs, one member of each pair of specimens was cut into shavings by hand with a sharp chisel. The shavings were extracted at room temperature for 4 hours with 10 milliliters of distilled water per gram of wood. The extracted solution was then decanted and its pH measured with a glass electrode. The actual pH of wood is not a well-defined concept, and the above procedure has been found in another investigation to give reproducible and stable results (Pankevicius, unpublished data). A similar procedure has been found satisfactory by Packman (26).

The other member of each pair was dried in a natural circulation chamber at 20° C. and 63 percent relative humidity. After reaching 12 percent moisture content, the specimens were reconditioned in saturated steam at 100° C. and then re-dried to 12 percent moisture content. Previous work has shown that small specimens reconditioned at 12 percent moisture content will absorb sufficient moisture to ensure full recovery (6). The weight and dimensions of each specimen were determined before and after the heat treatment, after drying and after reconditioning and re-drying. At the conclusion of the tests, the oven-dry weights of the specimens were determined.

Results

The variation of the acidity of the specimens with the experimental conditions of the heat treament is shown in Figure 1 where the pH of the extracted solution (10 milliliters water per gram of wood) is plotted against time of treatment at each temperature. The curves represent values calculated from equation (4) with the parameters listed in Table 1, whereas the points indicate the experimental results. Values of k_1 and k_2 for 38° and 54° C. have been obtained by extrapolation of the log k versus 1/T curves from higher temperatures (see equation 9).

An analysis of variance was carried out to determine the effect of temperature and time of treatment on pH and shrinkage, and significant differences between treatments calculated from the replicate-treatment interaction are given in Table 2. It will be noted that the values calculated from equation (4) fit the observations to within the significant differences, except for the 54° C. treatment of Tasmanian *E. regnans* and three individual results for *E. diversicolor.* The scattering with the latter species may be due to its high content of extraneous substances, but the deviation of the 54° C. treatment of Tasmanian *E. regnans* cannot be explained. It should be noted that the 54° C. treatment of Victorian *E. regnans* also showed a deviation towards lower acidity, though of smaller magnitude, and that similar deviations were observed for short-time treatments at 82° C.

Although the theoretical curve for the 137° C. treatment of Victorian *E. regnans* fitted the experimental points satisfactorily, the values of the parameters B and X_0 were not consistent with those for the other temperatures. Entirely consistent values are obtained if the 137° C. curve is adjusted by admitting a significant deviation of one point (3 days).

The apparent variation of X_0 with temperature is partly due to experimental errors in the reaction rate data, but the low values found in most cases at the lower temperatures probably result from the simplifying assumption of a single decomposing

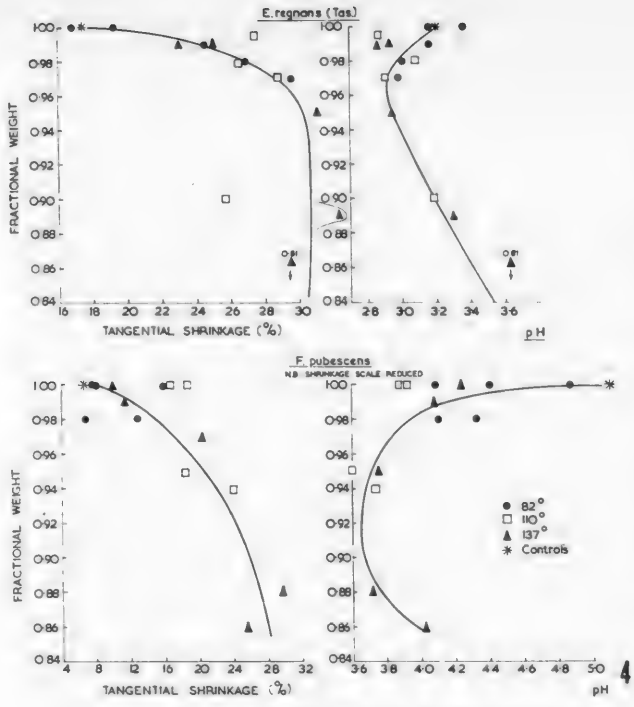


Fig. 4.—Relation of weight losses during heat treatments to tangential shrinkage and pH.

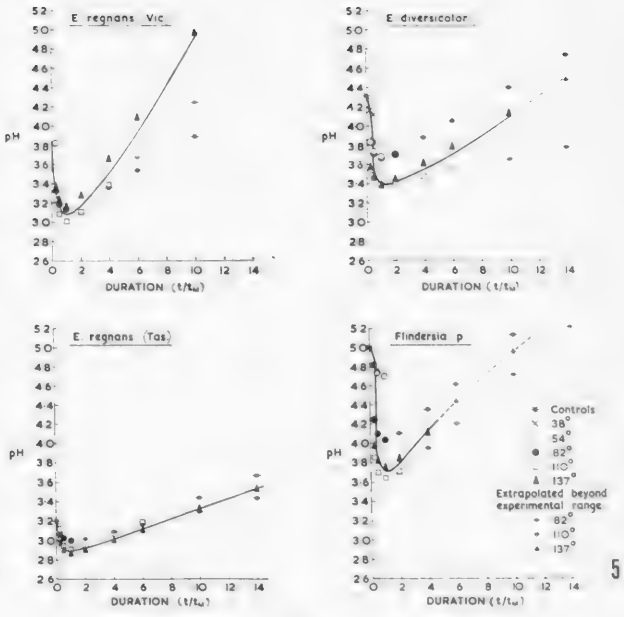


Fig. 5.—Variation of pH on reduced time scale.

substance, X, in equation (1), as noted before.

The observed pH can, of course, only be taken as a relative indication of the acidity of the wood. An observed pH of 3.0 would correspond to approximately 0.0007 grams dissociated acetic acid per gram of wood. The pH would also depend on the extent of buffering which may vary between trees and specimens. This variation may account for some of the scattering of the results (26).

Figure 2 shows the observed values of total tangential shrinkage. The curves represent free-hand fits of the observed points. Results obtained by Greenhill (4) have been included for comparison. Radial shrinkages showed the same trends of variation with time and temperature as tangential shrinkages. A few representative values are given in Table 3. The significant differences for shrinkages, obtained from the analysis of variance, are given in Table 2. Their comparatively large values are probably due to tree treatment interaction which could not be analyzed with the small number of trees in the present experiment. The variation in total shrinkage is mainly due to variation in collapse. However, after the more severe degradation treatments, the distinction between normal shrinkage and collapse becomes rather vague and difficult to observe.

Figure 3 gives the tangential reconditioning recoveries as a percentage of the difference between total shrinkage before reconditioning of the treated specimens and the shrinkage after reconditioning of the controls. This procedure assumes 100 percent recovery in the controls. It should be noted that, in fact, the recovery of the controls would be of the order of 90 percent (4, 6). However, the method of representation adopted here is considered to give the clearest picture of the effect of thermal decomposition on recovery. The scatter of the results at the lower temperatures for *E. diversicolor* and *F. pubescens* is due to the small absolute magnitude of collapse in these species which magnifies any small error when expressed as a percentage.

The weight losses of the specimens during the heat treatments were computed from the relation

$$W = \frac{100 + m_0}{100 + m}$$

where W = fractional residual weight.
m_0 = green moisture content (in percent) of untreated controls.
m = apparent green moisture content (in percent) before treatment of treated specimen, based on oven-dry weight after treatment.

Although this method relies on the accuracy of matching, the results were consistent with a linear variation of log W versus time, as required for a first-order reaction. However, the shrinkage did not increase indefinitely with weight loss but approached a maximum, whereas the pH decreased with increasing weight loss to maximum acidity and then increased with further weight loss. Figure 4 illustrates the relation between shrinkage, pH and weight loss for Tasmanian *E. regnans* and *F. pubescens*. Weight losses during treatments at 38° and 54° C. were negligible and have not been plotted. The two other woods exhibited the same trends.

A certain amount of drying and shrinkage occurred in the bombs during the heat treatments. In general, this did not exceed 20 percent moisture loss and 5 percent shrinkage, except in a few individual specimens. Analysis showed that the results were not significantly affected by drying during treatment.

Discussion

Variation of Acidity and Shrinkage: The results of the pH determinations (Figure 1) demonstrate clearly the simultaneous action of the acid-producing and acid-eliminating processes assumed in the theory. At the lower temperatures, the treatments were not continued long enough for

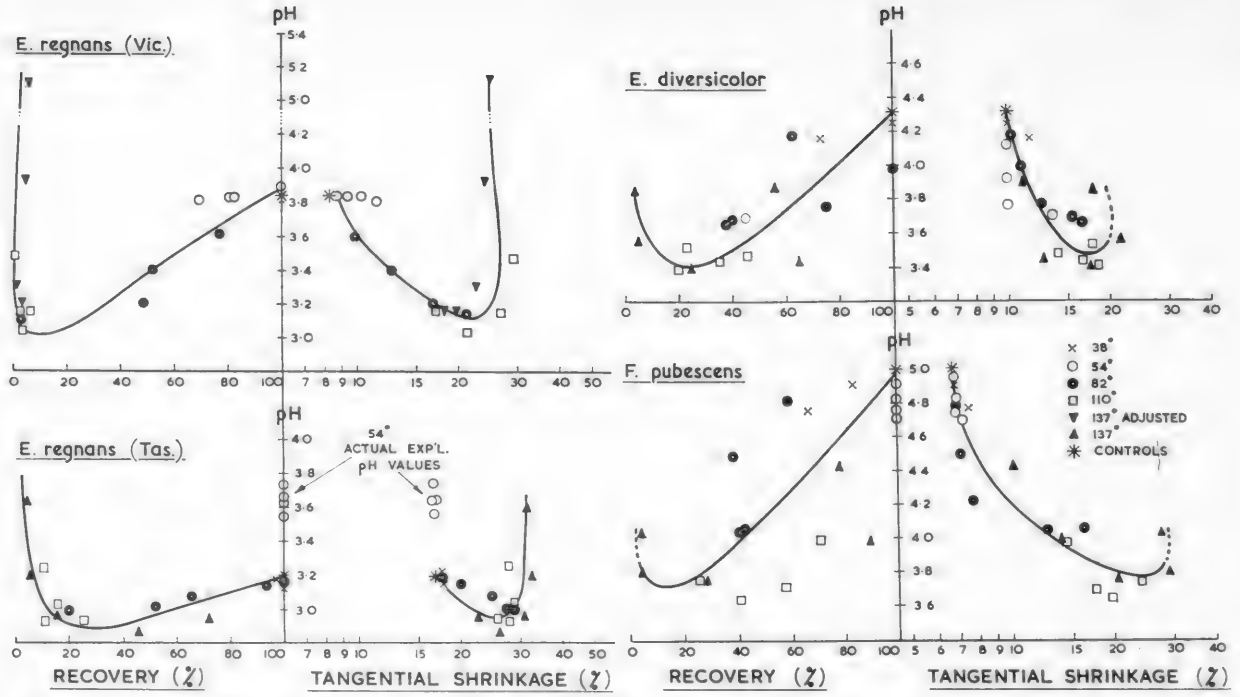


Fig. 6—Correlation between total tangential shrinkage, reconditioning recovery and pH. (Points for pH and shrinkage are taken from curves in Figures 1 and 2. Recovery in percent as in Figure 3.)

the latter to become important, but at the higher temperatures, acid elimination overtook production after a relatively short time. The difference between treatments at higher and lower temperatures is thus largely a matter of different time scales. Short treatments at high temperatures and long treatments at lower temperatures (above the threshold where thermal degradation becomes appreciable) produce similar effects. This may be demonstrated by reducing the pH curves for all temperatures to the same time scale. Figure 5 shows plots of the reduced results, obtained from equation (4) with τ ($= t/t_M$) substituted for t. If the rate constants k_1 and k_2 are multiplied by the observed time for maximum acidity (t_M), the products for all temperatures are of the same order of magnitude for each lumber over the experimental range (Table 1). The kinetics of the acidity changes will be further discussed in a second paper.

The results for acid production are qualitatively consistent with those reported by Packman (26).

The observations of total shrinkage (Figure 2, Table 3) and recovery (Figure 3) show the expected increase in severity and irrecoverability of col-

Table 1.—PARAMETERS IN THEORETICAL EQUATIONS

Material	Temperature (°C.)	Parameters X_0 Moles x 10^4	B	k_1 $(day)^{-1}$	k_2 $(day)^{-1}$	$k_1 t_{max}$	$k_2 t_{max}$
E. regnans (Victoria)	54	0.26	0.19	0.048	0.0015	1.7	0.054
	82	7.6	5.4	0.14	0.011	2.6	0.20
	110	11.8	8.4	0.70	0.11	2.1	0.33
	137	3.1	2.2	3.14	0.30	2.2	0.21
	137* (Adjusted)	10.4	7.4	1.20	0.38	1.6	0.50
E. regnans (Tasmania)	38	2.7	0.44	0.023	0.00043	2.9	0.054
	54	3.0	0.49	0.065	0.0014	2.8	0.060
	82	5.0	0.80	0.23	0.0067	2.8	0.080
	110	8.1	1.3	1.25	0.070	2.5	0.14
	137	9.3	1.5	3.11	0.13	2.8	0.12
E. diversicolor	38	0.43	0.86	0.063	0.0030	2.4	0.11
	54	1.9	3.8	0.15	0.0069	3.0	0.14
	82	2.2	4.5	0.28	0.022	2.5	0.20
	110	3.8	7.7	1.60	0.028	4.0	0.07
	137	4.6	9.3	1.35	0.10	2.7	0.20
F. pubescens	38	0.15	1.5	0.071	0.0098	1.8	0.25
	54	0.16	1.6	0.13	0.015	1.9	0.23
	82	1.2	12	0.22	0.030	2.2	0.30
	110	3.0	30	0.40	0.048	2.4	0.29
	137	2.4	24	0.55	0.083	2.2	0.33

*Disregarding result for 3 days treatment, see text.

lapse with increase in either the temperature or the duration of the treatment. The total shrinkage does not, however, increase indefinitely, but approaches a maximum which is not significantly affected by further increases in the severity of treatment within the experimental range. On the contrary, after the most drastic treatments, the total shrinkage seems to be a little less than after slightly less severe conditions (Figure 2). This effect, though statistically not significant for any individual curve, seems a little too persistent to be dismissed as entirely spurious.

The existence of an approximate correlation between total shrinkage, reconditioning recovery, and thermal degradation as indicated by the acidity of the wood is demonstrated in Figure 6. For greater ease of comparison, the plotted points for pH and shrinkage represent the smoothed values on the curves in Figures 1 and 2, but the scattering of the actual experimental values does not affect the overall trend.

It is particularly interesting to note that the total shrinkage increases appreciably only as long as the acidity of the wood increases. When the acidity begins to decrease, the shrinkage stabilizes at or slightly above the level reached for greatest acidity or decreases slightly. The recovery during reconditioning varied with pH similarly to the total shrinkage.

The radial shrinkage and recovery for all woods examined followed the same pattern of variation with pH as the tangential values.

Species Effects: The general pattern of behavior was the same for all woods investigated. The main feature of the collapsing species *E. regnans* was a greater sensitivity to temperature and a somewhat faster rate of both acid production and elimination at the higher temperatures. This caused the acid-eliminating process to have a greater effect than for the other species. The total shrinkage also showed a more rapid initial increase with *E. regnans,* and the percentage recovery a more rapid decrease. However, after the most severe treatments, the results for all three species were very similar.

It is interesting to compare the behavior of Victorian and Tasmanian *E. regnans.* The former collapsed very little without heat treatment (8.5 percent total tangential shrinkage) and was less acid (pH 3.63) whereas the latter collapsed more severely (17.4 percent total tangential shrinkage) and was more acid (pH 3.20). Comparison of the graphs shows that the material from both sources tended towards the same maximum values, but the Victorian material, because of its lower start, had a longer way to go and thus showed a greater variation.

Although in the material examined, the collapse in untreated specimens increased with the average acidity, the sample is too small to draw any general conclusions regarding the relation between collapse and acid content of trees. It is intended to undertake further investigations in this direction, as recent results by Stewart and associates (25) have indicated that a certain amount of hydrolysis may occur in standing eucalpyt trees.

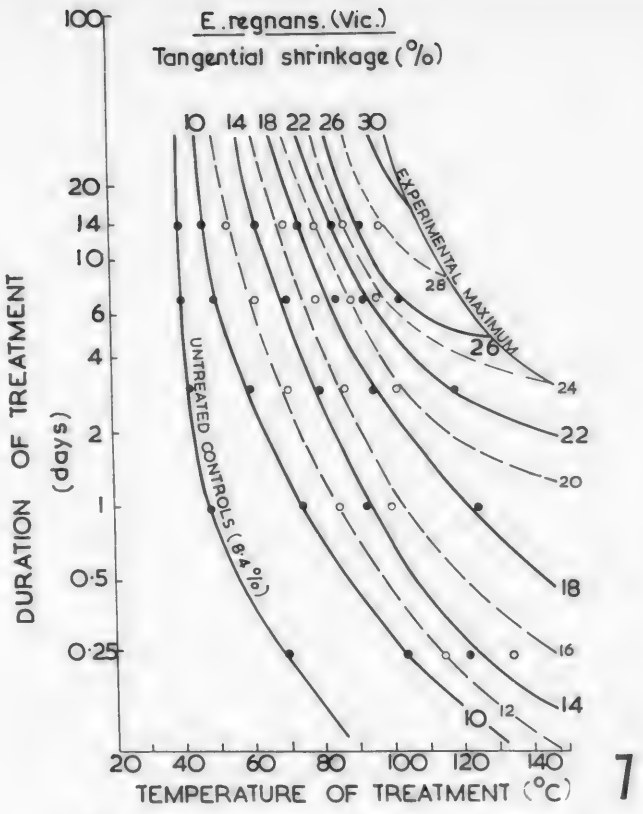


Fig. 7.—Range of variation of total tangential shrinkage in Tasmanian *E. regnans.*

Range and Mechanism of Variation in Collapse After Heat Treatment: A clear representation of the range of variation of total shrinkage is obtained by plotting lines of equal shrinkage on log t versus temperature coordinates, as is illustrated for Victorian *E. regnans* in Figure 7. It will be noted that unlike weight or strength losses (11), the shrinkage lines are curved and terminate at a point corresponding to the maximum

Table 2.—STATISTICALLY SIGNIFICANT DIFFERENCES

Material	Level, Percent	Shrinkage before reconditioning (Percent of green dimension)		Reconditioning recovery (Percent of green dimension)		pH
		Tangential	Radial	Tangential	Radial	Units
E. regnans (Victoria)	5	9.5	5.9	4.1	3.2	0.28
	1	12.8	7.9	5.5	4.3	0.37
E. regnans (Tasmania)	5	4.8	3.1	4.0	2.7	0.23
	1	6.4	4.2	5.4	3.6	0.31
E. diversicolor	5	5.5	2.7	1.2	0.57	0.23
	1	7.4	3.6	1.6	0.76	0.30
F. pubescens	5	6.0	2.4	2.7	1.7	0.28
	1	8.0	3.2	3.7	2.2	0.38

Table 3.—REPRESENTATIVE VALUES OF TOTAL RADIAL SHRINKAGE

Material	Duration of Treatment (days)	Temperature of Treatment (°C.) 82	137	Untreated Controls
E. regnans (Victoria)	3	8.4	9.5	5.3
	14	11.0	8.4	
E. regnans (Tasmania)	3	10.5	11.2	6.2
	14	13.1	10.5	
E. diversicolor	3	5.5	7.3	4.9
	14	7.5	9.0	
F. pubescens	3	3.4	7.4	2.8
	14	5.2	8.1	

for the particular duration and temperature. Admitting proportionality between shrinkage and hydrogen ion concentration, this result follows from the theory previously presented. From equation (4), it may be readily shown that the logarithm of time to reach a given hydrogen ion concentration is an approximately linear function of the inverse absolute temperature, with different coefficients for small and large times.

The mechanism of the increase in collapse after heat treatments may be surmised from Kauman's theory (6) which represents collapse, C, by a function of the form

$$C = p_1 (P - Q) + p_2 S_o \quad --(11)$$

where p_1 and p_2 are creep coefficients (ratio of deformation to applied load), P is the hydrostatic tension exerted by the controlling meniscus, Q is the compressive strength of the wood at the limit of plastic flow, and S_o is the collapse-free shrinkage. An increase in collapse may be brought about by a decrease in Q, by a decrease in the effective radius of the controlling meniscus which would increase P, or by an increase in p_1 and p_2. Calculation using plausible values of the parameters (6) shows that a decrease of 40 percent in Q could increase collapse by only about 25 percent. A simultaneous decrease of 40 percent in the radius would result in an increase in collapse by a factor of 2.5, but observations of drying rate do not give any evidence of a correspondingly large decrease in permeability of heat-treated wood. It is thus likely that a major proportion of the increase of collapse is due to an increase in the creep coefficients p_1 and p_2, although variations in P and Q undoubtedly contribute an important share.

From a morphological point of view, it is likely that the degradation of the more reactive hemicelluloses by heat treatments leads to a greater relative mobility of cell wall constituents and thus to greater total shrinkage. Recent work (28) with *E. regnans* has demonstrated that chemical degradation of hemicelluloses and lignin also results in increased total shrinkage and reduced reconditioning recovery.

Conclusions

Thermal degradation of green wood causes large increases in total shrinkage due to increased collapse during subsequent drying, and severely reduces the recovery obtainable by reconditioning. The acidity of the material measured after the heat treatment increases with temperature and duration of treatment up to a maximum and then decreases. The increase in shrinkage is roughly proportional to the increase in acidity up to the maximum. When the acidity decreases, there is no further change in shrinkage or loss of recovery. Species which normally do not collapse approach the behavior of collapsing species after exposure to heat treatments.

The effect of thermal degradation on shrinkage and recovery is highly significant for treatments exceeding 1 to 2 days at 82° C., 6 hours at 110° C., and about 2 hours at 137° C.

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NAMES in the NEWS

Keith F. Jensen, Ph.D. candidate in forestry at Iowa State University, Ames, Iowa, has been awarded a $600 fellowship grant for research. The award was made by Koppers Foundation of the Koppers Company, Inc., Wood Preserving Division, Pittsburgh, Pa. The purpose of the grant is to make research time available in the summer months for graduate students who plan teaching careers.

Eugene C. Dorsa has been appointed sales manager for Gray Products Company, Inc., Waverly, Virginia. **Eugene J. White** and **Jack D. Winkleback** have been appointed sales representatives for the firm. Gray Products Company manufacturers Graco Flakecore, Standard board and Underlayment board.

Oscar Witt, manager of stock and prices for Weyerhaeuser Company, Marshfield, Wis., and Vermont mills has been elected a director of the Hardwood Plywood Institute. The Institute is the national trade association of hardwood plywood manufacturers.

Alan C. Lundberg has been named credit manager for Southwest Forest Industries general offices in Phoenix, Ariz.

Bob Rickey, southern sales manager for Yates-American Machine Co., and **Dick Routon,** president and general manager of National Die and Machine Works, Inc., Memphis, Tenn., have organized a new company with headquarters in Memphis. The company will have general machine shop services and a waste saw and trim saw.

John Leo Scarry has been named Assistant General Superintendent, Primary Production, of the Riverdale plant of Acme Steel Company.

Benton P. Smith has been named vice president and director of Scott Paper Company's new affiliate in the Philippines, Eastern-Scott Paper Company. He will be replaced in his former position as export sales manager by **Robert X. Miller,** who has been associated with export sales since 1956.

Keith McCaffery, Stanley, Wisconsin, has been awarded the $1,500 Minnesota & Ontario Paper Company Graduate Research Fellowship in Forestry for 1961, according to **George Amidon,** woodlands director for the company, and **F. H. Kaufert,** director of the University of Minnesota's School of Forestry.

Robert B. Holder, a professional forester from Knoxville, Tenn., has been appointed director of administrative services for American Forest Products Industries, Washington, D.C. **C. A. Gillett,** managing director of AFPI, national sponsor of the American Tree Farm Program of growing trees as a crop on private lands, said Holder will be in charge of the association's forest industry relations.

Dr. Leonard Karel has been appointed Special Assistant to the Associate Director for Research, National Science Foundation. Dr. Karel will be responsible primarily for the preparation of staff studies on science resources planning. He will also assist the Associate Director in coordinating the Foundation's research grants programs and institutional programs, and in maintaining liaison with other Federal agencies concerned with the support of scientific activities. Dr. Karel came to the Foundation from the National Institutes of Health, where he had been Chief of the Extramural Programs Branch of the National Institute of Allergy and Infectious Diseases since 1951.

EMPLOYMENT *Opportunities*

This service is free to members of FPRS. Please keep items as brief as possible. The staff retains the right to condense or edit all items published free of charge. Display ads or boxed items are $8 per column inch.

Positions Offered

E–428—Wanted—an experienced salesman at least 30 years of age. Part-time travel in the eastern United States. Merchandise includes flooring and other wood products. Send complete resume to box number care of *Journal.* (Aug.–Sept.)

E–429—Want young forestry or agriculture graduates keenly interested in chemical sales development and service work leading to sales management in wood preservatives, coatings, herbicides, and fire-retardants. Complete resume needed. West Coast location.

E–430—Mechanical engineer with 5 years or more experience in mill operations and plant quality control wanted to assist in production problems, design and planning improvements. Prefer man with Southern background. Louisiana location in small town. Plant consists of sawmill planer, kilns, furniture dimension units.

Employment Wanted

647—Forester, age 25, seeks employment. Has B.S. degree from Pennsylvania State University, M.F. from Yale University. Single. Prefers western United States but will consider other locations. (Aug.–Sept.)

648—Wood technologist with B.S. and M.S. degrees from State University College of Forestry, Syracuse, desires to relocate in East or Northeast. Four years' experience in wood finishing, gluing, quality, and process conrol. Desires management, engineering or applied research position with progressive company. Married, two children, age 31. (Aug.–Sept.)

649—Graduate of University of Washington College of Forestry with B.S. degree in forestry wants sales or public relations work. Presently in Air Force and expects to be released no later than October, 1961; would be available for work in November. (Aug.–Sept.)

650—Wants plant superintendent or plant manager position. Fifteen years in management, age 33. (Aug.–Sept.)

651—Seeks employment in research, development, liaison, industry education, or public relations. Has M.S. degree, chemical research experience. Also experience in northeast state-supported agency advising industry, organizing industry education meetings, writing for wood industry, speaking, development work on bark.

653—B.S. in Industrial Wood Technology, University of Michigan, Aug. 1961. Wants to work on production control, motion-time studies, quality control and other production problems. (Sept. and Oct.)

654—Graduate of the New York State College of Forestry with B.S. in Wood Products Engineering. Eight years experience with a leading hardwood plywood company in quality control and technical engineering. Desires like position. Well trained in all phases of plywood manufacture. Age 37, stable, mature personality. (Sept. and Oct.)

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United States Borax & Chemical Corp., New York
United States Plywood Corporation, Brewster

NORTH CAROLINA
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Dominion Electrohome Industries, Ltd., Kitchener
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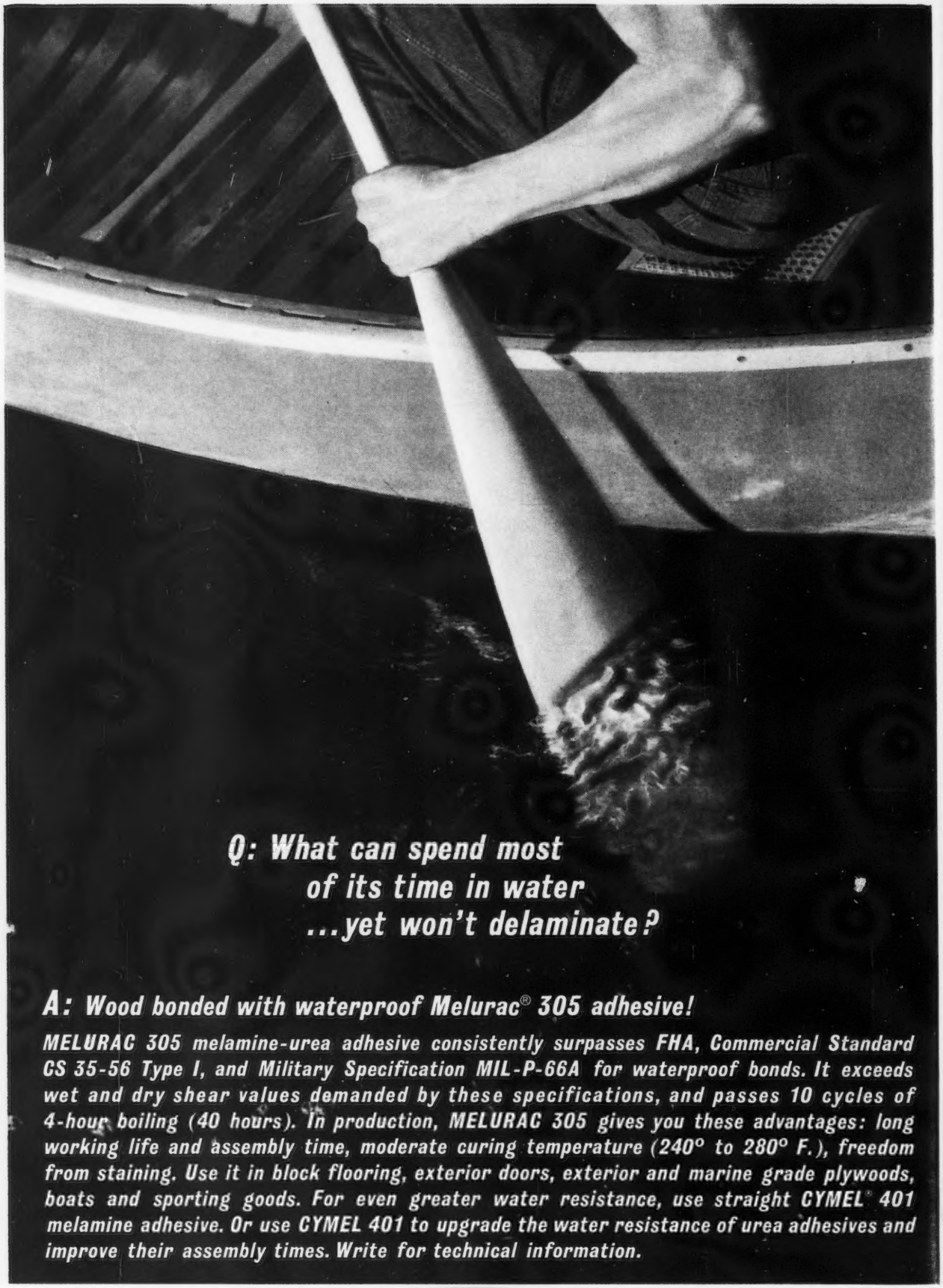

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